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SOME WAYS OF TEACHING PUPILS PRACTICAL HYGIENE.

BY E. L. MOSELEY,
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Nothing in the world is worth more than good health. The preservation of good health is possible only by right living. How to live in the right way is the most important thing for a child to learn. Many things he learns by experience, e. g., that he should not touch anything very hot, should not cut his skin, or put anything hard in his nose or eyes. Many things he learns by noticing the behavior of other persons and many from what he is told at home. The knowledge gained from experience, example, and home training is a very important part of his education, and for the child whose environment is exceptionally favorable, it would suffice for the maintenance of good health without any instruction at school pertaining to his body.

But more than 95 per cent of our pupils come from homes where, for one reason or another, they fail to learn some things pertaining to their bodily welfare which every person ought to know. If they do not obtain this knowledge in school they may die prematurely, or they may suffer from disease or from minor ailments which might have been avoided. In several ways the school can supplement the hygienic instruction which the child receives from other sources.

In the lower grades the teacher can see that the child goes outside at recess, can encourage him or her, if need be, to take an active part in play or other exercise, instead of encouraging him to study when the rest are at play. Each child should test or see someone test by means of a bit of cotton or tissue paper the ingress and egress of air in the room and be made to realize that air, though invisible, is as essential to life as is food. He should avoid a stooping posture when standing or sitting and know why. He should not face a light when reading or writing. If he needs glasses, he and his parents ought to know it. Commonly they do not. If his teeth need attention, they ought to know it. These and many other things pertaining to his bodily welfare the child should learn in the lower grades.

Somewhere in the grades or the high school, if not in both, there should be a course required for all students in anatomy, physiology, and hygiene. I cannot understand how any sensible educator can permit this course to be crowded out by other things. It is more important than algebra or Latin, or English grammar. The Chinese with few exceptions are ignorant of physiology, as they are of other sciences, and yet they live. The same was true of our ancestors. But in this enlightened country, in the twentieth century, are we to send out after twelve years in school, pupils who know nothing of the structure and function of their own ears and eyes except that without them they could not hear or see?

In a town in Africa I interviewed schoolboys, apparently about 12 years old, who could tell me about Louis Pasteur. In this country are we to turn out high school graduates who can name the wives of Henry the Eighth, but who have never heard of Pasteur or Koch or Chittenden? Are the adventures of Æneas at the court of Dido more important or more interesting than the discoveries of Reed, Carroll, and Lazear?

The course in physiology should be conducted by a teacher who is interested in it and will endeavor to make it of practical value to the students. The mere learning and reciting of lessons from the book may not be useless, but it should be supplemented by experiments, some of which the pupils can do at home and report on at school. A fresh heart and lungs should be obtained from a butcher and the lungs inflated. Each pupil should see the circulation in the web of a frog's foot or some other animal membrane. Models of the eye and several other organs should be examined. The application of the lessons to actual living should be discussed freely and the difficulties of properly applying the knowledge acquired should be overcome, if possible. The pupil while in the secondary school will not become much of an anatomist or physiologist but should acquire sufficient knowledge of these subjects to help materially in understanding hygiene.

In the Sandusky High School the study of physiology, supplemented in such ways as I have suggested, occupies half of the first year, so that all who enter the high school may get the benefit of it. In the fourth year we have recently introduced hygiene and sanitary science in connection with rhetoricals. It does not replace any other study. As heretofore, each student has rhetoricals twelve times each semester throughout his course, taking part himself with an essay, recitation, or debate three times each

semester. But in some of the rhetorical classes the subjects are no longer of a miscellaneous character.

In the first half of the senior year, the essays all pertain to matters of health and are followed by comments by the teacher and sometimes discussion by the pupils. The subjects include various diseases, their effects, their cause and how they may be avoided, the pupil choosing a subject, if possible, which he knows about from experience. Other subjects are: The most important factors in the maintenance of health, the most neglected factors in the maintenance of health, erroneous notions about health and disease, the length of human life, occupation, exercise, gymnastics, rest, sleep, worry, overwork, clothing, bathing, care of the eyes, care of the teeth, medical education, a doctor's experiences, trained nurses, medical frauds, patent medicines, what a city should do for the public health, and quite a list of subjects pertaining to food and drink. We believe that the pupils derive much valuable information from this course.

Once in several years we have a short course of lectures on health for the whole school.

Besides the lectures and courses devoted to health study, the pupils should be given useful bits of information on this subject as occasion offers in their other studies. There are many opportunities for this in chemistry and zoölogy, some in botany, and some in history.

Sometimes the excursions of science classes incidentally afford a means of seeing sanitary appliances with which the pupil is unfamiliar. Excursions for this express purpose might well be made by classes studying these subjects, e. g., to a city filtration plant, or a model dairy.

Last week I went after school with 57 botany pupils to study the trees on the grounds of the Ohio Soldiers' and Sailors' Home and get specimens of the leaves and fruit for their collections. Before we returned we went through the hospital and kitchen and a room where all the milk is sterilized by heat and then quickly cooled and aërated. On the Saturday excursions the pupils learn the importance of care in the selection of drinking water, the danger of sitting or lying on damp ground, the advantage of resting after lunch, the folly of lunching every few minutes or of drinking every time they see a pump and cup. The feeling of fatigue may be easily mistaken for one of hunger or thirst and the child who is not told this may be very slow to find it out. The novice is likely to return home more exhausted

from abuse of his stomach than by too much exercise. The interest which these excursions arouse in outdoor life leads to more of outdoor pursuits for pleasure or for business and thus may result in much benefit to health.

Pupils are more impressed by what they see than by what they read. They should see mosquito larvæ and know the source of the water containing them and how they may be killed. They should see trichinæ in pork or human flesh, also some protozoa and bacilli. They should have an opportunity to observe the growth of bacteria on a dish of gelatine over which a fly has been permitted to walk and another which has been touched with unwashed fingers. A few lessons in bacteriology might well be included in an elementary course in biology, so that the pupils may get some idea of the role of micro-organisms in nature and the conditions that are favorable for their development. People who have never seen these things can hardly appreciate their importance. A beam of light admitted to a darkened room through a small opening, illuminating the dust in its track, helps them to realize that many of the things around us we ordinarily fail to see.

Some Things Pupils Should Come to Understand.

A headache or toothache or any other ache or pain is a danger signal. To stop it with medicine that deadens the nerve is like pulling down the signal and allowing a train to rush on to destruction.

People usually do not need medicine even when they are not feeling well, but rest and perhaps different food and more fresh air.

In many cases doctors prescribe medicine not because they think their patients need it, but because they expect it and would not be satisfied without.

Patent medicines, no matter how cleverly advertised, are generally useless and most of them harmful.

It is very unwise to suffer from a decayed tooth for fear of pain that would be inflicted by a dentist.

Ailments such as colds, headaches, and indigestion which fail to improve when the supposed cause is removed should not be allowed to persist without consultation with a conscientious physician. The longer they continue, the more difficult they are to cure. Neglected minor ailments often lead to serious disease.

The most common mode of infection in the case of diphtheria, scarlet fever, typhoid fever, and several other diseases is by contact with a patient or something soiled by his saliva or other secretions or excreta. The ways in which contact infection may occur are very numerous, but if food and eating and drinking utensils were not contaminated with anyone's soiled hands or lips, and if fingers, pencils, etc., were not brought to the mouth, several of these diseases would become much less common than they are.

Night air is not dangerous, not even in a malarious district, if the person is protected from mosquitoes by screens.

Those who accustom themselves to fresh air indoors, night and day, and spend considerable of the day out of doors, suffer less from colds and other ailments than those who live in unventilated rooms.

Liability to sore-throat and colds is not lessened but increased by wearing warm wraps around the neck.

A potent factor in the production of colds and several other ailments is overeating, especially of proteids.

Some proteid food is essential, but most persons in this country eat two or three times as much of it as is good for them.

Lessening the amount of meat consumed not only lessens the cost of living but enables the person to live much better.

There is no need of eating more eggs or cheese when the quantity of meat is reduced.

Eating hurriedly is a bad practice. One should come to the table with such an appetite that bread and other ordinary foods will taste good and should enjoy the taste of each mouthful until it has been thoroughly masticated and mixed with saliva.

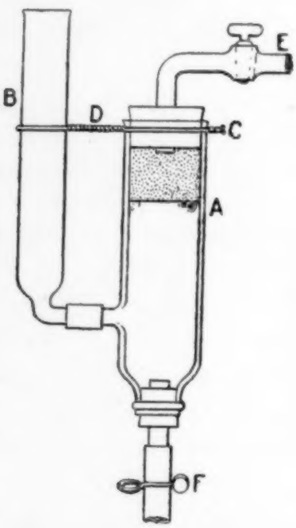
Tea, coffee, and tobacco are bad for children and for many grown people. Probably all would be better off without them.

Scientific investigations in recent years have shown that the moderate use of alcohol is somewhat injurious. Furthermore in a very large number of cases the moderate use of alcoholic beverages leads to their immoderate use. In the London County Insane Asylums the number of patients and staff increased between 1889 and 1906 from 8,107 to 19,457, but the consumption of malt liquors decreased from 255,486½ gallons to, 1,281½ gallons, of wine from 6,687 pints to 265 pints, of spirits from 8,529 pints to 1,741 pints.

A SIMPLE AUTOMATIC GENERATOR FOR CARBON DIOXIDE OR HYDROGEN SULPHIDE.

By William M. Blanchard,
DePauw University, Greencastle, Ind.

The generator is easily made from a broken condenser jacket of a Liebig condenser and is readily understood from the drawing. It is but another illustration of the conversion of a broken and apparently worthless piece of apparatus into something useful—another instance of the utilization of the "scrap heap." By means of a hot iron rod or stout wire the jacket is cut in the usual way and the rough edge smoothed and flanged in a good flame. By means of a very small blast flame the glass is heated at three points about two inches above the side tube and little projections are made by gently pushing in the softened glass by means of a file or stout iron wire. These projections[1] will support a perforated piece of thick rubber, such as may be obtained from any plumber. This stout perforated rubber plate will serve as the support for the marble or ferrous sulphide. The tube B is made from a piece of large glass tubing; a large calcium chloride tube or an ordinary "adapter" will serve the purpose. This tube is held in position by means of a twisted copper wire, D. The apparatus is supported by an ordinary condenser clamp.



To remove the spent acid in the lower part of the generator, close the tube B with the thumb, or with a cork, open E and then F.

The apparatus is cheap, easily made, and easily cleaned and will prove very convenient where large quantities of gas are not required.

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[1]The projections at A should be lowered to about half the present distance above the lateral opening.

THE CHEMICAL LABORATORIES OF HEIDELBERG AND BONN.

By Nicholas Knight,
Cornell College.

It was a privilege to visit the great chemical laboratories of Heidelberg and Bonn on a vacation trip during the past summer. The semester had not closed, but the weather was unusually warm and only a few students were at their desks in the laboratory; besides many were behind in their duels, and were busy making up back work in this important adjunct of Heidelberg University life. It may be remarked in parenthesis that the system of dueling as practiced in all the German universities shows far fewer fatalities than the American football.

Heidelberg University has grown in recent years, and now there are about two thousand five hundred students in all departments. We were surprised to learn that there had been only one hundred and fifty in the chemical department during the year, including, of course, the students in pharmacy and medicine, who are obliged to take the first part of their chemical work in the universities. This is a small number as compared with the twelve hundred to fifteen hundred students in the chemical departments of some of the large American universities.

The Heidelberg laboratory is not an imposing building, and in this respect does not compare favorably with some of the great American laboratories. But the important thing, after all, is not the building and its equipment, but the teacher and the students. Readers of this magazine well understand that many of the world's greatest and most valuable scientific achievements have been wrought out in an humble and unpretentious place; while some of the most costly and imposing laboratories have not been conspicuous for the quality of the work they have turned out.

The German educational authorities always consider the *man* in making up their faculties, and their scientific and educational results seem to justify their methods. The aim is to secure a man who has accomplished something, who is a great authority, or better yet the greatest authority in some line of endeavor, who is still actively engaged in investigation, and in making contributions to the world's advancing knowledge. It has been learned by experience that such men are able to inspire students to do their best, and to bring out the best that is in them.

Is it not possible that in some sections of our country too much emphasis has been placed on buildings and material equipment and not enough on the man behind the gun—the professor? Yet

there are signs of change in these directions and better results may be expected.

The oldest part of the present Heidelberg laboratory was built by Bunsen in 1853 and '54. Another part was added by Victor Meyer, whose premature death the scientific world has not yet ceased to mourn, and now Professor Theodore Curtius, the present able head, has been obliged to build a second addition. The work has expanded, especially in the direction of physical chemistry, and more room is constantly required. The director lives in commodious rooms in the second story, the first being occupied as a part of the laboratory. A plate on the house informs the passer-by that *hier Wohnte Professor Robert Wilhelm Bunsen.* Professor Curtius is a genial man, in the prime of life, and he seems to take pleasure in showing an oil portrait of Bunsen, with the proverbial cigar between his lips, which Curtius says is considered a very excellent likeness of the great master of science.

The University of Heidelberg is beginning the five hundred and twenty-sixth year of its history. It is still young, active, and vigorous, and seems to be doing its full share toward promoting the high educational standards and ideals that have made the German university cities the Mecca of scholars from all parts of the civilized world.

We had many times visited the Heidelberg laboratory, but this was our first stop at Bonn. It is a larger and newer university than Heidelberg and has an interesting collection of buildings. It, too, is growing rapidly and claims an enrollment of four thousand five hundred students. The members of the royal family attend this university, which may help to account for its rapid development. Its chemical department also seems small as only one hundred and eighty students took the work last year. The laboratory is quite new, modern, well arranged, and convenient in every detail. Professor Richard Anschütz has been the head and director for a number of years, succeeding Kekulé, if our memory is not at fault. Kekulé was very highly regarded, as indeed he should be. His work on the benzene ring brought fame and recognition to the institution. A well-executed statue of Kekulé is near the main entrance to the laboratory. Anschütz attends to the revision of Richter's organic chemistry, and is one of the leading organic chemists of the present day.

Possibly science and art blend harmoniously. At any rate the name of Beethoven, the great musical composer, is intimately associated with Bonn on the Rhine, the seat of this famed university.

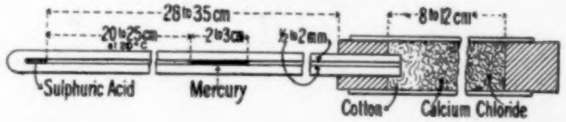
THE REMOVAL AND AN EXPLANATION OF DIFFICULTIES WITH THE "VOLUME COEFFICIENT OF EXPANSION" APPARATUS.

By Albert E. Hennings.

I am not recording a unique experience in stating that I have encountered serious difficulties in the construction and use of the familiar "volume coefficient of expansion" apparatus consisting of a capillary tube in which a column of air is confined by a thread of mercury. It is quite generally recognized that water vapor is a disturbing factor to subdue which it has become a common practice to enclose with the air a small quantity of concentrated sulphuric acid. Yet notwithstanding this precaution it is only in the case of tubes newly and carefully made up that any confidence can be placed in the observations. The resulting values of the coefficient are almost invariably too high; with the range 0°C. to 100°C., errors of 10% to 12% are not infrequent. Apparently the sulphuric acid does not serve the purpose for which it is intended.

This is a grave situation; but it is not a hopeless one. It shall be my purpose in what follows, *first,* to give information as to means whereby it may be relieved, and *secondly,* to carry the diagnosis to the point of ascertaining wherein previous efforts have failed.

1. By the simple expedient of surrounding the opening of the capillary tube with calcium chloride, its *whole* interior is shielded from moisture. The most troublesome and only per-



sistent difficulty is thereupon removed. The accompanying diagram suggests the manner in which the parts of the apparatus are assembled. A tightly fitting stopper placed in the mouth of the larger tube, except when observations are being taken, makes it possible for a single charge of calcium chloride to serve almost indefinitely while the whole assemblage remains always in perfect condition. It is ready for service on demand, and once in working order becomes a valuable and permanent addition to the equipment. Tubes prepared in this way have given entire satisfaction. Such discrepancies as appear in the final

results are well within the range prescribed by the probable errors in the measurements of the temperature and volume.

2. Without this final precaution the presence of water vapor is inevitable. It may be accounted for in part by assuming that the mercury index picks up moisture in its excursions back and forth and brings some of it into the enclosed space. Again, to take proper account of the highly hygroscopic property of glass, it is necessary to assume further that the index, in moving outward, passes through and leaves behind it a tubular film which disintegrates with the rise of temperature. The water vapor thus introduced adds its pressure to that due to the air alone. The sulphuric acid does indeed fail to meet the situation. In the few minutes in which the experiment is performed, it does not become operative as a drying agent, for with the air under atmospheric pressure, the diffusion of the vapor along the axis of the capillary tube takes place *very slowly*.

The latter assumption and the accompanying argument find justification in the fact that when a tube made up in the usual way is placed in a steam bath, the mercury index very shortly reaches a maximum height which it maintains apparently for an hour or more. It then subsides very slowly and in the course of several hours reaches a point which indicates a decrease of 2% to 5% in the expansion. This effect is less pronounced or may disappear entirely in the case of the older tubes or those not so carefully made up. The explanation to be offered here is that the sulphuric acid and the water taken up by it form a solution which has an appreciable vapor tension. While this may not be perceptible at room temperature, it becomes very much so at the temperature of steam.

OUR QUICKSILVER PRODUCTION.

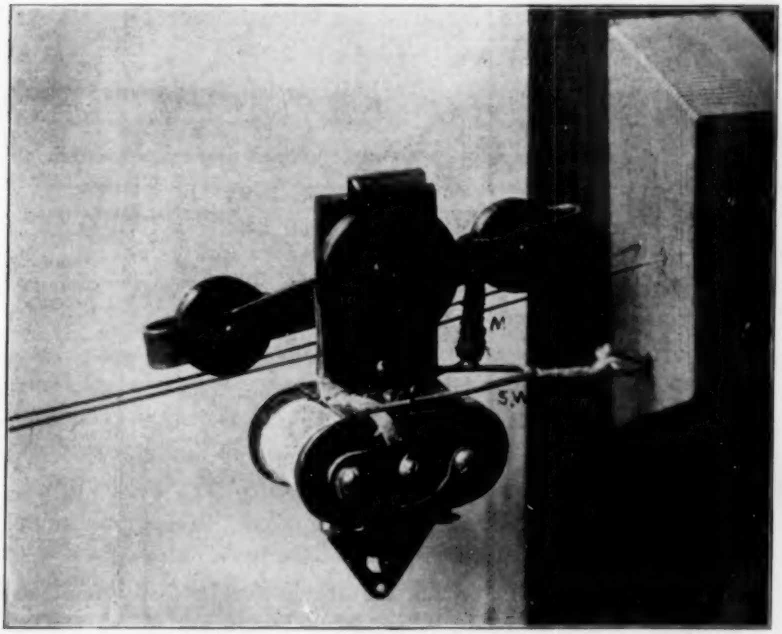
The world's production of quicksilver last year was 3,747 short tons, of which the United States produced 773 short tons. Quicksilver is usually quoted in "flasks," a flask containing 75 pounds. The American production therefore represents 20,601 flasks. Of this amount California furnished 17,211 flasks. In 1850 the quicksilver production of that state was 7,723 flasks, but California's greatest production was in 1881, when the yield was 60,851 flasks.

In 1910 only two countries produced more quicksilver than the United States—Italy 882 tons and Spain 1,102 tons. These and other statistics are given in an advance chapter on quicksilver from "Mineral Resources of the United States, 1910," by H. D. McCaskey of the United States Geological Survey.

GIBSON'S ACCELERATION APPARATUS.

By Dell Gibson,
Lyons, Nebraska.

This machine is designed to run down inclined *wires* and to record its exact position at the end of each second. It consists of an electro-mangnet mounted on pulleys. One pulley connects with one terminal of the wires of the electro-magnet and the other with the other terminal; the pulleys being insulated from each other. The starting wire is shaped like this figure. One end of the starting wire (s. w.) is in front and lies under the marking wire, or the wire at the top of the armature. The other end goes behind the machine and hooks into a hole in the back of the machine. When a current is sent through the machine this wire is thrown back and the machine is released. The marker (M) is attached to the armature and is made of light chamois smeared on the inner side with printer's ink. The



inclined wires are parallel and lie in a common plane with each other. The upper terminal is shown in the cut. The lower one has a turnbuckle for tightening the wires. The lower terminal block is fastened to a clamp which may be secured to any part

of a 2x4 stick 5 feet long securely fastened to the wall. By this means any desired pitch may be given the wires. The inclined wires are insulated from each other but connected in series with a battery, a seconds pendulum and perhaps a sounder to make the seconds audible. A key is also in the circuit. When all has been arranged the key is closed. At the beginning of the first second when connections are made the armature is drawn down and strikes the release wire setting the machine free. At the same time the marker indicates exact position of the machine at starting. At each succeeding second the exact position of the machine is marked the same as the first one.

There are many machines which work well in theory, but very poorly in practice. This one works better in practice, however, than it does in theory. In my own work with the machine the error were less than one per cent. With the pupil's work the errors were nearly all within two per cent. There is no possibility of their making greater error than in the measuring of the distances from mark to mark. I think even better results could be secured with better apparatus. The seconds pendulum was a homemade affair. There is small chance of error. Even the error of the friction of the machine may be accounted for and thus eliminated in calculating *g*. The lower terminal is moved up and down till a place is found where the machine, when started by hand, continues to mark off equal distances. This is then used as the point from which the measurements are made in calculating the slope of the wires.

The machine possesses the following advantages over any other acceleration machine which I have seen:

(1) It is striking for class demonstrations as it can be rapidly adjusted and worked before the class. It is an interesting individual experiment as all individual experiments are interesting where the student can see something in *motion*.

(2) It occupies small space. It can be placed over a blackboard or across a window. When not in use the lower terminal may be unhooked and hung up out of the way.

(3) It can be used to illustrate accelerated and uniform motion in the same act by having a bend in the middle of the inclined wires.

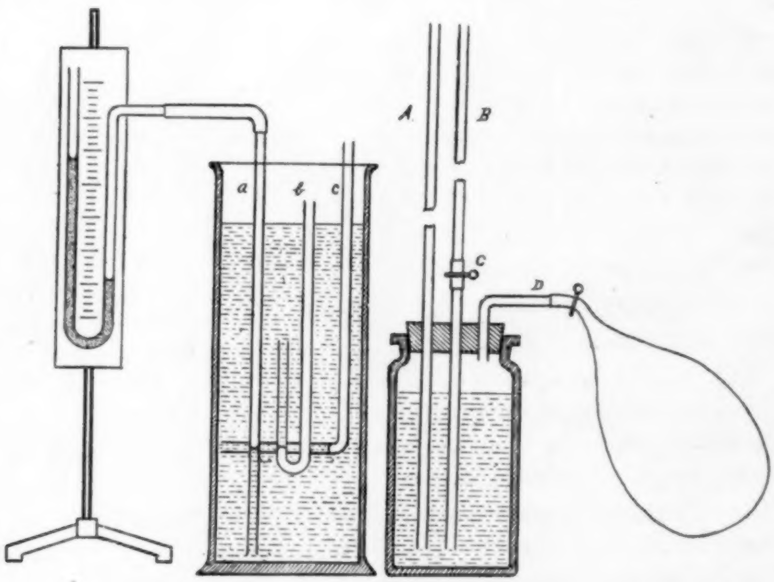
(4) It is easily operated.

(5) It is not approached for *accuracy*. Even the novice can not only *prove* laws but easily *deduct* them.

EXPERIMENTS IN FLUID PRESSURE.

By H. C. Krenerick,
North Division High School, Milwaukee, Wis.

Many have found the usual method of verifying the law of fluid pressure at a point with the J form tubes and mercury unsatisfactory both in results and reasoning. If the tubes are bent as shown in Carhart and Chute and many other text-books, different volumes of air are confined in the three short arms, hence if the pressures were equal the mercury displacements would not be the same. Another objection is that a water column always enters the tube, consequently, with the different shaped tubes, the contact between water and air, the real pressure area under consideration, will not be at a constant depth thus the pressure varies. Furthermore as this area of contact becomes horizontal in all three tubes we are in each case dealing with a downward pressure.



The following modification of the experiment eliminates these objections and may be of interest to some. The three glass tubes, *a, b,* and *c* of Fig. 1 are of the same length and cross section. The tubes *b* and *c* are bent at such points that the short arm will be longer than the entering column of water. If the three tubes are held in the liquid as shown in diagram, it is

very apparent that the volume of confined air is the same in each trial; that the direction of pressure on the confined columns of air is upward, downward, and vertical; that the area of pressure in each case is at a constant depth, thus a constant pressure. The open manometer containing colored water or alcohol is here used for indicating pressure.

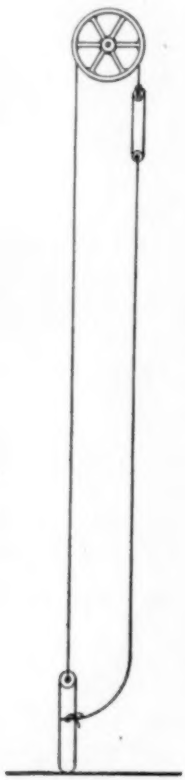
Another experiment with the apparatus is to have a tube of twice the cross section and one half the length. This tube when compared with *a*, with the pressure area at the same depth, indicates the same pressure change, thus an application of Pascal's Principle.

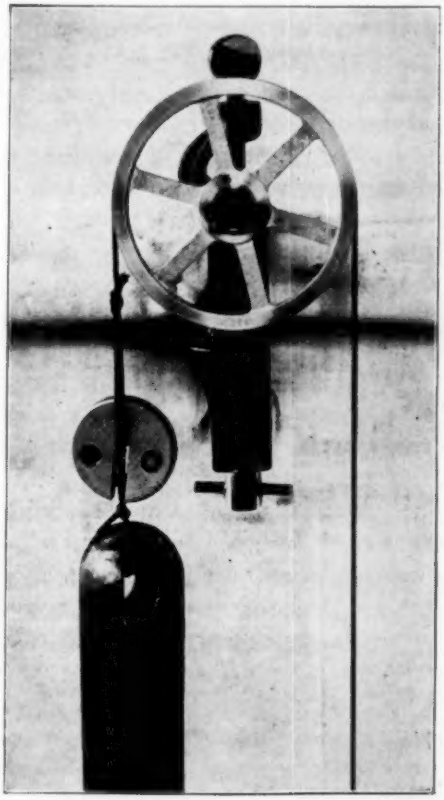
The following experiment I have found an interesting and instructive application of Pascal's Principle and other laws of fluid pressure. The nature of the apparatus is clearly shown in the drawing, Fig. 2. Tubes A and B are at least five feet in length. Colored water is used in the bottle. The pinch clamp at C is at first closed, then by blowing through D the liquid is raised as high as possible in A. The clamp is now opened and the majority of the class will reason that the two columns can be lifted to only one half the height of the single column. When the two columns go up to the same height some are skeptical. To convince them that it was not the result of a greater effort, I force as much air as possible into a football bladder and connect to D with the clamp at C closed. The liquid rises to a certain height in tube A. When the clamp is opened the first column remains stationary and the second column rises to the same level. By replacing B with tubes of different cross section and by supporting the tubes at different angles, the relation of pressure to vertical height or head is clearly demonstrated. The last is rather strikingly shown by using the bladder with both tubes open. A is left vertical and as B is inclined at various angles the level of the two columns remains the same.

A LABORATORY EXERCISE TO VERIFY THE LAWS OF ACCELERATED MOTION AND TO PROVE f = ma. DESIGNED FOR HIGH SCHOOL CLASSES.

By Philo F. Hammond,
High School, Snohomish, Wash.

This exercise was suggested to me by Prof. F. A. Osborn, head of the Department of Physics, University of Washington, and he kindly loaned me a pulley to try out the exercise in our high school laboratory. Having tried it out and having convinced myself that it is a satisfactory exercise for high school work, I purchased a pulley for our own use.





An aluminum pulley 10 cm. in diameter is securely mounted within a few inches of the ceiling. Over this pulley two large cylindrical weights (window weights or car coupling pins) are suspended by a heavy braided fish line. These weights should be

smoothed off and then ground down on an emery wheel until both weigh the same within one tenth of a gram. An extra cord may be tied to the weights near the bottoms to counteract the weight of the other cord as it runs over the pulley. The cord supporting the weights should be so adjusted that the weight at the top will be within a few inches of the floor. The extra cord, spoken of above, should be so adjusted that when the loaded weight hits the floor, it becomes taut. This will prevent the weight then at the top from jumping and throwing the cord off the pulley.

A weight (say 50 gms.) is then placed at the top of one of the large weights in a loop made in the cord for this purpose and then drawn to the ceiling. The student operating the apparatus stands with a stop watch in one hand and holds the cord with the other. Upon counting three, he lets go of the cord and presses the stop watch at the same time. The weight carrying the over weight drops to the floor pulling the other up to the pulley. At the instant the weight hits the floor, the student presses the stop watch and records the time. This is repeated ten times and an average is then taken. This may be repeated with different overweights to suit the desires of the instructor. The distance the weight passes over is easily measured by the use of two thin strips of board (1″x1″) held side by side, with one end of one strip upon the floor, while the other strip is pushed upward until it touches the bottom of the weight near the pulley.

Having obtained the space and the time of falling, "*a*" may be obtained from the formula $s = \frac{1}{2}at^2$. Multiplying this by the total mass moved we have the force in dynes.

The student is then told to deduct a certain number of grams from the overload (without being told why) and to reduce the balance to dynes. This amount, to overcome friction, should be carefully determined by the instructor beforehand. The force thus obtained should, of course, agree with the one obtained above.

After the student has worked out two or three values in this way he is given a list of questions for answers and computation as follows:

Questions.
(*General.*)

1. Is this an example of a freely falling body? Give reasons for your answer.

2. Why was 25 grams subtracted from the "overweight" to determine the correct force?

3. Why do we consider the overweight (less 25 grams) the force causing acceleration when there is a mass of over 4,000 grams on the same side of the pulley upon which the force of gravity is acting?

From the trial giving the best results answer the following questions. Give formulæ and substitutions used in determining the answers.

1. What was the final velocity of the weights? Determine in two ways, using force in one determination.

2. Assuming the mass and the force to be correct, what ought the acceleration to be?

3. What was the kinetic energy of the system the instant before the weight hit the floor?

4. Prove your result of number (3) by comparing its potential energy just before the weights started to move.

5. If the two above values are not the same, give cause of error.

6. What is the momentum of the system the instant before the weight hit the floor?

7. Point out all possible sources of error (*a*) in taking data, (*b*) in defects of operation and apparatus.

I have used this exercise for the last two years in the Snohomish High School Physics Laboratory, and find that the average student will get values having errors ranging from a small fraction of 1% to about 10%, with probably an average of less than 5%. These I consider very satisfactory results. A light aluminum wheel is used and no account is made of its inertia. The weights that we use are 4.1 kilos each, making the total mass moved over eight kilos. The stop watch was purchased of a local jeweler for $7.50. The pulley and supports may be obtained of any of the dealers advertising in this Journal. The cost of these to us was $5.45. The stop watch is unnecessary, although we found it use more satisfactory than the seconds pendulum which we used at first.

The following are sets of data taken in this laboratory which are representative of the work done:

DATA TAKEN BY EDITH WEAVER AND HAZEL ALCORN.

Space					Time in sec.	Acc. in cm.	Mass in gm.	Force in dynes	MxA:	Error	% Error
Trials				Mean							
1	2	3	4								
344	344.	343.5	344	343.87	12	4.77	8221	39200	39255	55	0.15
320	316	317	315	318.25	10	6.365	8231	49000	52389	3389	6.9
308.7	310.4	309.4	309	309.4	9	7.64	8241	58800	62961	3261	5.4

Note: This work was done before a stop watch was secured. The spaces were adjusted by means of an adjustable stand, so that the weight hit the stand coincident with the click of a seconds pendulum, making the time a whole number of seconds.

DATA TAKEN BY VARIAN SHAW AND OTTO SPRAGUE.

Time		Space cm.	Acc. per sec.	Total mass	Force in dynes	Dynes MxA	Error Dynes	% Error
Trials	Mean							
14.2 14.0 14.2 14.0 14.0 14.4 14.2 14.2 14.0 14.0	14.12	346	3.46	8210	29400	28406	994	3.3%
10.0 9.8 9.9 9.9 9.8 10.0 9.9 9.8 9.9 9.8	9.88	346	7.08	8241	58800	58346	454	.7%
8.1 8.0 8.0 7.9 7.9 8.0 7.9 8.1 8.0 7.9	7.98	346	10.86	8271	88200	89023	823	.9%

REPORT UPON THE TEACHING OF PHYSICS IN SEGREGATED CLASSES.[1]

At the Cleveland meeting of the Central Association of Science and Mathematics Teachers, a committee was appointed to study and report upon the teaching of physics in segregated classes in coeducational high schools. In order to include the work of the last school year, the collection of data was deferred until this fall. Early in September letters were sent to the larger cities of every state in the Union except three, calling attention to the work of the committee and to the teaching of physics in segregated classes in various parts of the country, and requesting the coöperation of the persons receiving the letter. Enclosed with the letter was a stamped, self-addressed post card containing in addition to the spaces for the name and address of the sender the following four questions:

1. Has physics been taught in segregated classes in your schools? Yes. No.
2. If so, will you coöperate further? Yes. No.
3. What were your results with boys?...... Girls?......
4. Do you wish the final report of the committee? Yes. No.

Some 150 letters were sent out. One hundred replies were received, and of these twenty-two were from teachers willing to coöperate further, who reported segregated classes in physics in coeducational high schools.

Eight were from Atlantic Coast States, ten from the Central States and four from Mountain and Pacific Coast States, showing a somewhat surprisingly even distribution from ocean to ocean. To each of the twenty-two was sent a letter and a list of questions and from these sixteen replies have been received.

It is, of course, well understood that the questionnaire cannot determine facts of a high degree of scientific accuracy. There are, however, some situations, and the present investigation appears to be one, in which the questionnaire presents a means of determining the extent, the tendencies, and the apparent success of a new educational procedure.

With the idea of making this report complete, the list of questions employed is inserted here. In the blanks sent out, space was left after each question sufficient for the answer.

1. Name of teacher reporting.
2. School.
3. Address.
4. Date.

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[1]Read before the Physics Section of the Central Association of Science and Mathematics Teachers, Dec. 2, 1911, at Lewis Institute, Chicago.

5. Number of segregated classes taught.

6. Extending over a period of ....semesters.

7. Were *mixed* physics classes taught at the *same time?*

8. Were the same *topics* studied in all courses?

9. If different courses were given, how did the courses differ?

10. Do you favor (*radical*) *modification* of the course for *girls?* If so, suggest topics to be *omitted* and those to be *emphasized.*

11. Ditto for *boys.*

12. What *subjects* in physics do *girls* handle best? *Boys?*

13. On the average does the girl or the boy do *better work* (a) when the *courses* are *identical*? (b) When the courses are differentiated for sex?

14. In your experience with *mixed* classes have you had a larger *percentage* of *failures* with *boys* or with *girls?* If possible give exact percentages in each case.

15. Ditto for segregated classes (a) with identical courses? (b) With differentiated courses?

16. In general is *instruction* more or less *effective* in *segregated* as compared with *mixed* classes? (a) when the segregated classes have the *same course?* (b) when *differentiated courses* are given?

17. Is *discipline* easier or harder in *segregated* as compared with *mixed* classes? (a) With girls? (b) With boys?

18. What differences in aptitudes, if any, have you found between boys and girls? (a) In preparing for recitations? (b) In solving problems? (c) In laboratory work? (d) In applying problems and laboratory work to practical affairs? (e) In acquiring facility in *laboratory technique?* (f) In recording work in laboratory books? (g) In developing a *scientific habit of thought* when new topics are presented?

19. Is the *laboratory* (inductive) method of study equally well adapted to boys and girls?

20. Is the recitation (deductive) method of study equally well adapted for both?

21. Is the demonstration experiment equally adapted for both?

22. What is the attitude toward segregation? Of boys? Of girls? Of parents?

23. Observations not covered by the foregoing questions.

The *sources of information* in any questionnaire are of value and interest, hence the inclusion here of the following list, which

contains the names of many of the high schools reporting: Brookline, Newton, and Dorchester Center, Mass.; Bridgeport, Conn.; Richmond, Va.; Toledo, Dayton, and Cincinnati, Ohio; Chicago, Ill.; Duluth and Winona, Minn.; St. Joseph, Mo.; and Oakland, Cal.

The *experience* of the teachers reporting should be known. Those replying have taught from 1 to 13 segregated classes in physics, with an average of 4 classes. This experience has varied from 1 to 6 semesters with an average of 2½ semesters. Two thirds of the teachers reporting have taught mixed classes along with their segregated ones and are therefore in a position to make careful comparisons. Three fourths of the teachers used the *same topics* in all classes, while in nearly every case the *treatment* of these topics was differentiated for the segregated classes. In fact, as one teacher expresses it, "It is impossible to teach a girls' class as one would a boys' class." Many of the teachers state that what is needed is not so much a difference in the topics studied as a difference in the *treatment* and *emphasis* of the topics considered, to make the work most effective for the boy and for the girl. While many urge a modification of the treatment of topics for girls, but one believes the present course for boys requires much change. In other words, the persons reporting seem fairly well agreed that the present physics course is a *boys'* course and on the average is fairly well adapted to them, while with girls a differentiation of the treatment and emphasis is found to add to the effectiveness of its presentation.

With respect to the *subjects in physics,* there is quite general agreement that *boys* handle mechanics and electricity best and a number add heat to the list. There is also a consensus of opinion that *girls* do well in heat, sound, and light, some adding molecular physics and "the topics of especial application about the home."

Under conditions present in *mixed* classes, the boy is believed to do better work by a majority of those reporting, while in *segregated* classes there is a preponderance of opinion that the girl holds her own and often makes a better showing than the boy.

A striking situation was developed in the report upon the *percentage of failures,* these showing a variation of from 3% to 35% in the several reports. One teacher reports that in his mixed classes 12% of the boys and 35% of the girls fail, and

he adds, "Not many girls take physics because there are so many electives which may be substituted." Another teacher who has had in his department 8 segregated classes for two semesters reports failures, boys 10%, girl 5%. Another reports having 35% of failures in mixed classes, 25% in segregated classes but with same courses, and 16% failures in segregated classes with modified or differentiated courses. Still another reports with mixed classes, failures, boys, 3.6%, girls, 5.4%; in segregated classes, boys, 2.5%, girls, 3.1%.

Whatever else is indicated by these failure reports there is shown a great difference in assigning grades between the teachers of different cities. It would seem that when the percentage of failure among third and fourth year high school pupils runs as high as one third of the class that there is something at fault somewhere.

In *comparing* the *effectiveness* of *instruction* in mixed and segregated classes, all but one of those reporting state that the instruction is *more* effective in segregated than in mixed classes both with boys and with girls.

Concerning the *ease* in *discipline* in mixed and segregated classes, one third report that it is easier in segregated, one third say that it makes no difference, and the remainder say that it is harder in segregated classes. Since the chief problem in discipline is settled when the pupil is interested and active, instruction especially adapted to his needs should lessen any difficulties of discipline. Perhaps the variation in replies upon this point may be accounted for by the fact that experience has shown that some teachers are adapted to handle girls' classes, others boys' classes, while some do well with either. A teacher's success with mixed classes, strange as it may seem, is no certain criterion of his results with segregated ones.

Respecting the *aptitudes* of the two sexes, all but one state that the girls are more faithful and prepare their lessons better than the boys. All but two, however, give boys credit for solving problems better than the girls, especially originals. One says that the girls do better when a "model" problem is given. A majority agree that *laboratory work* appeals better to the boy than to the girl, though some say that there is little real difference between them and that it depends upon the exercise or experiment.

One third of those reporting believe that the boys are better

adapted to the *laboratory* or *inductive* method of study while as many others believe there is no difference between the sexes on this point; the remainder express no opinion.

One half say that the *recitation* or *deductive* method of study is better adapted to the girls, though nearly as many believe that there is little difference here.

There is general agreement that the demonstration experiment is equally adapted to both. Concerning the *attitude of the pupil toward segregation* but five reported, all of these saying that it was favored by the pupils.

As in every questionnaire, some questions have been raised to which the answers show no consensus of opinion. This may be illustrated by the answers to the question, "Does the boy or girl do better work in physics?" One half say the boys, one fourth the girls, and one fourth that there is no difference. *The percentage of failures* also shows great variation, though too few answered this to give a complete expression of practice. The two reporting both on mixed and segregated classes show about two thirds the failures with segregated classes as with mixed. This incomplete report upon the percentage of failures emphasizes the fact that teachers do not as a usual thing sufficiently appreciate the importance of preserving their records in order that the statistics therein contained may be available when needed. The *facts* from school records speak for themselves, while *opinions* are often discounted.

Concerning the aptitude of boys and girls for the inductive or laboratory method of instruction and the deductive or recitation method, little of agreement was obtained.

On the other hand, there seems to be what may be called a consensus of opinion upon several topics:

First, there appears to be substantial agreement that *radical* modification of the course in physics is not desirable for either the boy or the girl.

All but one say that boys excel in *applying problems* and laboratory work to practical affairs. The one says that girls do better in segregated classes.

That the boys acquire facility in *laboratory technique* easier than girls is the observation of two thirds of those reporting, though some find little difference.

On the other hand, all but one report that the girl prepares a *neater record* of her laboratory work than the boy.

Second, while this is true, there is also a general expression of opinion from most of those who have taught segregated classes more than two semesters that the ***treatment*** of the topics presented in the girls' classes should be considerably modified, especial attention being given to heat, sound, light, and molecular physics and "the physics of the home," as one man puts it as distinguished from "the physics of the shop." "More domestic science applications" is the suggestion of another. Another says that his work in girls' classes "differs in method of presentation and illustration."

Third, There is general agreement that the present course is well adapted to boys, particularly if "practical applications" and the "physics of the shop" are emphasized together with the subjects of mechanics, heat, and electricity.

Fourth, All but one of the replies to the question: Is instruction more or less effective in segregated as compared with mixed classes? state that the instruction in segregated classes is more effective. Some are quite emphatic about it.

Fifth, Concerning the *aptitudes* of boys and girls for different phases of the work in physics, it is generally agreed that boys are better in laboratory work, in problems, in practical applications, in developing a scientific habit of thought, and in developing facility in laboratory technique; while the girl is more careful and conscientious and better prepares her home work and laboratory notes.

Sixth, All of those reporting the attitude of the pupils toward segregation state that the pupils favor it. Several say they do not know. I believe it is a good thing to go sometimes to your own pupils for information. One teacher reports: "Boys and girls are applying for segregated classes to start next semester." Another: "My girls say they feel freer to express themselves when by themselves." Another: "Active workers prefer segregation."

In conclusion, this question has shown a widespread interest in the question of segregating boys and girls in high school classes in physics. Practically all of those who have tried the plan give favorable reports and express no intention of abandoning the plan, on the contrary, many are enthusiastic about it. One says: "This is our first trial of segregated classes in physics. So far I have found it a great improvement over mixed classes." One teacher speaks of the advantage of greater freedom of expression in segregated classes and the more nearly equal expe-

rience of the class when reciting. Another refers to the opportunity that segregation gives for the right amount of time and emphasis upon important subjects; one sex requiring more time than the other for developing the ideas and principles. Still another states the situation in the usual mixed classes admirably: "One of the chief obstacles to the best success in the teaching of physics is the heterogeneous character of the class. The fund of experience, the interests and aptitudes, and the present and future needs of the pupil are factors which should largely determine the matter and the method of the course, and these factors, as they apply to the different individuals of a typical physics class, are irreconcilably different. To compromise difference on the basis of the average pupil, is lamentably unsatisfactory; for the average pupil, so far from being in the majority, is—like averages in general—a mathematical fiction."

Many teachers who have not tried the plans are seriously considering the advisability of doing so. Here are some of the expressions in their cards and letters:

1. "We are considering the matter. Prefer to wait for reports."
2. "We are going to try it."
3. "Favor scheme, cannot segregate."
4. "We are hoping to segregate in the future."
5. "Have thought of trying segregation. Would like very much to have the report."
6. "Intend to follow such a plan in the evening schools."
7. "If I could be free from college control I would try to give the girl such portions as have the strongest appeal to her and have considerable cultural value at the same time. If free from the restraint just mentioned, really a positive embargo, I would give to the average high school boy a course in *practical* physics in the full sense of the term. I would try to contribute my share toward giving him something to make him feel in later life that the content of his high school work was 'worth while.' Such a course could be culturally quite as strong as the affected 'pure' physics most of us present."

A summary of the results of this questionnaire indicate:

1st, That in segregated classes radical modification of the topics of the course in physics is neither necessary nor desirable.

2nd, The treatment of the topics presented should be adapted to the needs of the individuals in the classes.

3rd, The present course in mixed classes is better adapted to boys than to girls.

4th, Instruction in segregated classes when properly conducted is more effective than in mixed classes.

5th, In general, boys and girls show different aptitudes toward different phases of the work in physics.

6th, The pupils like segregation.

7th, There is a healthy spirit of inquiry and investigation concerning the most effective methods of teaching physics in many of our progressive high schools.

This investigation indicates that segregation has resulted in more efficient teaching. Whatever of improvement may have been occasioned by segregating the classes in physics; undoubtedly some of the increase in efficiency has been due to the stimulus that always comes when teachers study the effectiveness of their work while employing a new educational procedure.

RECOMMENDATION.

Practically all of the teachers who have reported upon segregated classes in physics show that increased efficiency has resulted from the plan.

This committee therefore recommends to physics teachers the desirability of trying at the first opportunity the following educational experiment:

Arrange your pupils in physics so that you have a class of boys, a class of girls, and if possible, as a basis for comparison, a mixed class. Or, this may mean a boys' or a girls' class with a mixed class.

It may make the inauguration of the plan easier if it is announced that the *same topics* will be considered in all courses, but that the *treatment* of these topics in the segregated classes will be such as to make the work more helpful to the boys and girls concerned.

It may also simplify the matter to call the boys' course the science course; the girls' course the domestic science or normal school course; and the course for the mixed classes the general course.

Any teacher trying the experiment is requested to report the results of the experiment to this committee. If possible, give percentages of grades and failures. Include as well the results of other tests of efficiency that may be employed.

WILLIS E. TOWER, *Chairman.*
CHAS. M. BRONSON.
FRANK E. GOODELL.

MATHEMATICAL ENCYCLOPEDIAS.

By G. A. Miller,
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In comparison with the past this is an age of mathematical encyclopedias. Yet the work is going on so quietly that few people realize the enormous amount of energy that is now being devoted toward the preparation and publication of great mathematical works of reference. It is true that the English-speaking people have thus far had only a very minor part in this great recent development which started in Germany about fifteen years ago and is at the present time being advanced in France with even greater vigor than in Germany, while Italy has taken important steps toward further progress.

Recently the great publishing firm of B. G. Teubner, Leipzig and Berlin, which sends out from its presses about two and a half million books yearly, issued the fifteenth edition of its circular in reference to the great encyclopedia bearing the title: "Encyklopaedie der Mathematischen Wissenschaften mit Einschluss ihrer Anwendungen." This circular describes both the German and also the French edition. The latter edition is not merely a translation of the former. In fact, parts of it are so much enlarged and changed that one scarcely thinks of the original in reading this, while other parts have not been materially altered. The French edition aims to retain the essential traits of the German edition and to take account of the French traditions and habits as regards lucid exposition.

The vastness of the work may be inferred from the fact that the published parts of the German edition would fill more than a score of volumes of four hundred pages each although a large part of the field has not yet been covered; and, judging from the parts of the French that have appeared this edition will be at least twice as large as the German. For instance, the number of pages in the published parts of Volume I of both of these two editions are as follows; the first number applying to the German edition. Fundamental principles of arithmetic 27, 62; combinatory analysis and determinants, 19, 70; irrational numbers and convergence of infinite processes with real numbers 100, 196; ordinary and higher complex numbers, 37, 140; infinite algorithms with complex numbers, 8, 20; theory of sets 24, 42; finite discrete groups 19, 85.

The object of this great work of reference is to give as completely as possible the fully established mathematical results and

to exhibit by means of careful references the historical development of mathematical methods since the beginning of the nineteenth century. The work is not restricted to the so-called pure mathematics, but it includes applications to mechanics, physics, astronomy, geodesy and various other technical subjects, so as to exhibit *in toto* the position occupied by mathematics in the present state of our civilization.

While such a vast work will naturally appeal to those interested in higher mathematics more than to those whose main interests are confined to the more elementary subjects, yet the latter will find much that is within their easy comprehension, especially in the introductory parts of arithmetic, geometry, and algebraic analysis. Moreover, it is of considerable value to read things once and a while which are not within one's easy comprehension. Great thoughts can sometimes be enjoyed even by those who cannot comprehend them completely, and a superficial view of the vastness of the developed parts of mathematics may sometimes suffice to replace a large part of our self-conceit as regards our attainments by a spirit which is much more valuable for our own development and which saves our friends from much annoyance.

Those who are inclined to be discouraged at times by the lack of general interest in mathematics should take new courage from the fact that there was a considerably greater demand for the German edition than had been expected. In fact the supply of the first volume, covering more than a thousand pages, has already been exhausted although the entire work is far from being complete. The publishers are advising those who are interested to secure the first volume in French and state in their announcements that the French edition is both larger and better than the German. It is encouraging to know that this great work has been made accessible to such a large number of readers since its use must tend to raise very materially the standard of other mathematical publications. Anyone who offers for publication as new things contained in the great encyclopedia may find sympathy for his ignorance but he is not apt to find an excuse for it.

The Italians have started a large encyclopedia on elementary mathematics and the firm of B. G. Teubner expects to bring out a German edition of this work also. As it is now planned it will consist of forty-four mographs bearing the following headings: Logic of mathematics; elementary arithmetic; theory of numbers; the notion of number and its extensions; limits, series, con-

tinued fractions, and infinite products; progressions and logarithms; literal calculus and algebraic identities; combinatory analysis, determinants, and linear equations; equations whose degrees exceed unity; algebraic problems and their discussion; elements of the infinitesimal calculus; relations between analysis and elementary algebra; elementary properties of plane and space figures; theory of measure and applications; geometry of the triangle and of the tetrahedron; regular and star polygons and polyhedrons; elementary geometric transformations; linear systems of circles and spheres; geometry on the sphere; sections of the cylinder and the circular cone; maxima and minima in geometry; methods of solution of geometric problems and classic problems; foundations of elementary geometry; circular and hyperbolic functions, and plane and spherical trigonometry; vectorial calculus; elements of analytic geometry; elements of projective geometry; elements of descriptive geometry; special curves and surfaces; non-Euclidean geometry; non-Archimedean geometry; geometric representation of complex numbers; relations between elementary geometry and the theories of higher geometry; units of measure; numerical approximations and graphic calculus; calculus of probability and the theory of errors; elementary applications of mathematics to the physical sciences; mathematics of statistics; mathematics of finance; history of elementary mathematics; didactic methods and text-books; mathematical recreations; instruments; models.

From these headings and from the standing of the men who have undertaken the preparation of these monographs, it appears that Italy and Germany, in view of the German edition, will soon have a work which will be extremely useful to the teachers of secondary mathematics. It is to be hoped that these activities in other countries will tend to attract attention to the great need of similar works in English. Those whose main interests are in higher mathematics are generally in position to use the works in other languages, but this is not generally true as regards those whose main interests relate to the more elementary subjects. Hence the need of an English encyclopedia on secondary mathematics is especially demanding attention and it is to be hoped that this need will receive due consideration in the near future.

The developed parts of mathematics are getting so extensive that the problem of transportation is becoming more serious and more complicated. In the early days books sufficed. These may

be compared to the heavily loaded and slow stages of the past. They were followed by the periodicals which correspond to railroads as regards the improvement as to more rapid and better service. With this improvement has come a very large increase of traffic just as has been the case as regards railroads. We now need more books on books, corresponding perhaps to our telegraphs and telephones, if we are allowed to carry the above comparison a step further. The whole intellectual life of the world is affected most profoundly by improvements as regards transportation of intellectual advances, and this furnishes a reason for being deeply interested in the present movement toward great mathematical encyclopedias.

THE IMPORTANCE OF MATHEMATICAL TRAINING TO SCIENCE TEACHERS.[1]

BY A. F. CARPENTER,
University of Washington.

Every individual capable of exercising that function of the mind called judgment has a creed, even though he may never have gone so far as to formulate it into a profession of faith. From the mathematical standpoint at least, the man who says, "I believe nothing," possesses a creed in just as true a sense as the one whose articles of faith would fill a volume. Indeed, the former has a decided advantage over the latter when it comes to giving reasons for the faith that is in him. In view of this fact it will be the part of caution to base the present discussion on a creed consisting of but a single article and on one also to which teachers of science will no doubt subscribe, namely—science teachers should have the first word and the last word not only in the matter of their own training but also in fixing upon the most satisfactory methods of presenting the subject-matter to their students.

It is the purpose of this paper to criticise neither the one nor the other. It is quite unnecessary to assume that the average teacher of physics has had insufficient mathematical training, in order to prove that a considerable amount of that same training will be of great benefit to him. Neither must it be maintained that the average teacher of chemistry is igno-

[1]Read before the Mathematics Science Section of the Washington Educational Association, December, 1910.

rant of mathematical methods of presentation, in order to show that those same methods may be used to advantage in his classes. Neither assumption is to be made; and if at any point the spirit of criticism becomes manifest it will be found, when traced to its source, to emanate not from mathematicians but from those very men whose scientific standing is unquestioned.

Finally, it must not be supposed that an attempt to show wherein science teachers will benefit by mathematical training is equivalent to a denial of the truth of the converse proposition. Quite as much might be said on the importance of scientific training to mathematics teachers. No one who has taught mathematics for any considerable length of time will deny that his success in that direction depends in a great degree upon the thoroughness with which he has mastered the sciences.

To speak positively, the intention is to establish the necessity for mathematically trained teachers of science by showing: first, that mathematics is nothing less than nature in the abstract; second, that to think scientifically is to think mathematically; third, that the natural sciences can best be presented to the student by those methods which should characterize the teaching of mathematics; fourth, that mathematics furnishes the best and only available symbolism for accurately expressing scientific truths; and fifth, that important advances and new developments in many branches of science can most reasonably be hoped for through the application of mathematical principles. It is hoped also to indicate in a general way the minimum of mathematical training consistent with success in the field of science teaching.

That every phenomenon in nature as seen and interpreted by the human mind has its exact counterpart in mathematics, is a statement which is difficult to prove and equally hard to controvert. To prove its falsity it is not sufficient, as might at first be supposed, to show up an instance in which it does not hold, since such a disproof would presuppose not only that mathematics in its present state permits of no further development, but also that the mind is incapable of error in interpreting the natural phenomenon in question. On the other hand, illustrations of the truth of the proposition are plentiful.

For centuries astronomers supposed the earth to be the center about which revolved the sun, moon, and stars, and to account for the eccentric motions of some of them, the the wise ones were kept busy inventing explanations. For centuries, too, had the mathematicians been admiring the beauties of the conic section as displayed by its many properties. But one day it was discovered that the explanation of the one was indeed the application of the other and that for ages before man began to contemplate the heavens, the planets had been swinging abcut their elliptic orbits obeying mathematical laws yet undiscovered by the human mind. But vast dimensions are not a prerequisite for the workings of nature. Quite as startling changes are brought about in the twinkling of an eye and the fraction of an inch as ever transpired during millions of years over unthinkable distances. The chemist, dealing with nature in her minutest manifestations, was long aware of the existence of certain unknown laws governing the velocity of chemical reaction. The truth was finally revealed in a differential equation. That most common phenomenon of the physics laboratory, harmonic motion, is but the material exemplification of the periodic function concept in mathematics. Specific instances need not be multiplied. The study of nature in any of its phases is necessarily a contemplation of that most salient feature of natural phenomenon—change, variation. But variation is the foundation upon which has been built the most important single branch of mathematics, the calculus. Calculus is truly "the mathematics of nature," Kepler but formulated the truth which all scientists must acknowledge when he said, "The laws of nature are but the mathematical thoughts of God."

A single type of thought characterizes all scientific investigations whether they be physical, chemical, biological, or indeed any one of the score or more branches constituting the natural sciences. Primarily the mind must grasp the situation, it must perceive correctly existing conditions and decide, in a general way at least, the end toward which the investigation is directed. Next, having observed carefully the results of a sufficient number of experiments, it must sift out and systematically catalog those facts which have a bearing on the question at issue. By a proper association of these facts after careful scrutiny to avoid errors, it must then draw whatever conclusion is possible. Finally it must enumerate

all variations of the conclusion under different combinations of initial conditions. The exact similarity between this type of thought and that by means of which mathematical investigations are carried forward is striking. The mathematician must understand his data and should be able in a measure to anticipate the nature of his results. By applying already known mathematical laws to the data in hand, that is, by mathematical experimentation, observing at the same time the results of their applications, he is enabled to choose from them and arrange carefully such facts as point toward the desired end. This being done, the conclusion is a necessary consequence and it remains only to round out the investigation by citing all cases possible under the original assumptions. John Stuart Mill makes clear the relation of mathematical to scientific methods of thought. He says,[1] "The value of mathematical instruction as a preparation for those more difficult investigations, consists in the applicability not of its doctrines but of its methods. Mathematics will ever remain the past perfect type of the deductive method in general; and the applications of mathematics to the simpler branches of physics furnish the only school in which philosophers can effectually learn the most difficult and important portion of their art, the employment of the laws of simpler phenomena for explaining and predicting those of the more complex. These grounds are quite sufficient for deeming mathematical training an indispensable basis of real scientific education, and regarding, with Plato, one who is ἀγεωμέτρητος, as wanting in one of the most essential qualifications for the successful cultivation of the higher branches of philosophy." To quote again,[2] "It is only through mathematics that we can thoroughly understand what true science is. Here alone can we find in the highest degree simplicity and severity of scientific law, and such abstraction as the human mind can attain. Any scientific education setting forth from any other point is faulty in its basis."

A discussion of methods of teaching would be quite out of place here. No one method may be used to the exclusion of all others and the best method is the one which produces the best results. While differences in class room methods

[1] J. S. Mill, Systems of Logic, Bk. III, Chap. XXIV, paragraph 9.
[2] Comte, Positive Philosophy, Bk. I, Chap. I.

will be determined to a great extent by the subject-matter discussed these differences are reduced to a minimum in a comparison of methods used in mathematics and the natural sciences. The study of mathematics requires quite as much inductive as deductive reasoning, and it should be taught with that truth constantly in mind. A teacher of a class in mathematics should explain as little of the theory and illustrate with as few examples as will give the student an insight into the work in hand. The student is then in a position to solve for himself a list of problems, varying in detail and of increasing difficulty. Careful inspection of the results of a sufficient number of such problems will enable him to formulate, with fair degree of accuracy, the general principle, which may then with the teacher's oversight and suggestion be worked out deductively. By reading "science" for "mathematics," "perform" for "solve," and "experiment" for "example" and "problem," the preceding sentences will be found to describe with surprising accuracy a successful method of conducting class work in the sciences, one, indeed, which with slight variations is used in the majority of cases. President Remsen, in his address before the American Federation of Teachers of Mathematics and Natural Sciences,[3] emphasized the applicability of the methods of mathematics to the teaching of the sciences. He said in part, "The second important defect in the present teaching of chemistry in college is the absence of repetition. There is a little about a great number of things. We cover too much ground; the student gets only a veneer. Knowledge of this sort is not of much use and the drill given by such study is not effective. We must introduce into science teaching the drill element that comes only from repetition that is characteristic of mathematics."

The wonderful progress made in every phase of life during the last hundred years has been possible only through the increasing use of symbols. To-day, only the common laborer works entirely with the actual things. Those who occupy more remunerative positions in the business world work very largely with symbols, and in the professional world the possession of and ability to use a set of symbols is a prerequisite of even moderate success. The work of a man's hands remains after the worker has gone but the products of mental

[3]Ira Remsen, Presidential Address before the American Federation of Teachers of Mathematics and Natural Sciences, Dec., 1908.

labor are lost unless they are preserved to the world through some symbolic medium. It may be said without fear of successful contradiction that the language of mathematics is the most widely used of any symbolism. The man who has command of it possesses a clear, concise, and universal language. Fallacies in reasoning and discrepancies in conclusions are easily detected when ideas are expressed in this language. The most abstruse problem is immediately clarified when translated into mathematics. To quote from M. Berthelot,[4] "Mathematics excites to a high degree the conceptions of signs and symbols—necessary instruments to extend the power and reach of the human mind by summarizing. Mathematics is the indispensable instrument of all physical research." But not only physical but all scientific research must avail itself of this same instrument. Indeed, so completely is nature mathematical that to him who would know nature there is no recourse but to be conversant with the language of mathematics.

That the scientist has already recognized the value of mathematics as a scientific language is apparent, although a full recognition of this fact has come only within the last fifty years. In speaking of that monumental work by J. Willard Gibbs, "On the Equilibrium of Heterogeneous Substances," Bumstead says,[5] "It is quite out of the question to give, in brief compass, anything approaching an adequate outline of this remarkable work. It is universally recognized that its publication was an event of the first importance in the history of chemistry, that, in fact, it founded a new department of chemical science. * * * Nevertheless it was a number of years before its value was generally known; this delay was due largely to the fact that its mathematical form and rigorous deductive processes make it difficult reading for anyone, and especially so for students of experimental chemistry whom it most concerns; twenty-five years ago there was relatively only a small number of chemists who possessed sufficient mathematical knowledge to read easily even the simpler portions of the paper. * * * At the present time, however, the great value of its methods and results are fully recognized by all students of physical chemistry."

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[4]M. Berthelot, Science as an Instrument of Education, Popular Science Monthly, Vol. 51, p. 253.

[5]Scientific Papers of J. Willard Gibbs, Historical Note.

Present-day scientific research is being carried forward quite as much from the mathematical standpoint as through purely experimental methods nor is it reasonable to suppose that further advances can be made without the assistance of mathematical processes. The discovery of the planet Neptune was a mathematical victory and was prophetic of the part which mathematics was later to play in the advancement of science. Professor J. J. Thomson, speaking before the British Association for the Advancement of Science,[6] said, "I do not for a moment urge that the physicist should confine himself to looking at his problems from the mathematical point of view. * * * But two points of view are better than one, and the physicist who is also a mathematician possesses a most powerful instrument for scientific research with which many of the greatest discoveries have been made; for example, electric waves were discovered by mathematicians long before they were detected in the laboratory. * * * Again, it often happens that we are not able to appreciate the full significance of some physical discovery until we have subjected it to mathematical treatment, then we find that the effect we have discovered involves other effects which have not been detected and we are able by this means to duplicate the discovery. Thus, James Thomson, starting from the fact that ice floats on water, showed that it follows by mathematics that ice can be melted and water prevented from freezing by pressure. This effect which was at that time unknown was afterward verified by his brother, Lord Kelvin. Multitudes of similar duplications of physical discoveries by mathematics could be quoted." Addressing the same body, H. J. Smith[7] said, "I often find the conviction forced upon me that the increase of mathematical knowledge is a necessary condition for the advancement of science, and, if so, a no less necessary condition for the improvement of mankind. It could not argue well for the enduring intellectual strength of any nation of men, whose education was not based on a solid foundation of mathematical learning, and whose scientific conceptions or, in other words, whose notions of the world and of the things in it were not braced and girt together with a strong framework of mathematical reasoning."

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[6]J. J. Thomson, Presidential Address, British Association, for the Advancement of Science, Aug. 27, 1909.

[7]H. J. S. Smith, Presidential Address, Sec. A., British Association for the Advancement of Science.

Granting, then, that the scientist engaged in research work must be conversant with a considerable amount of mathematics, what shall be said of the science teacher? The combination of successful teacher and productive investigator is a rare one. The average teacher not only has too little time for research, but the very nature of his routine work militates against the possibilities of successful investigation. Yet it is possible and indeed imperative, not only that he obtain for himself a broad and comprehensive knowledge of science, but that he maintain a live interest in the work of those who are "extending the frontiers of science." This can be done only by constructive and systematic reading both of advanced texts and current scientific literature. And it is here that the science teacher will require his mathematics. J. W. Mellor, in his work on "Higher Mathematics for Students of Physics and Chemistry,"[8] says, "It is almost impossible to follow the later developments of physical or general chemistry without a working knowledge of higher mathematics." This text, acknowledged by physicists and chemists as a standard, makes use of an unexpected variety of mathematical conceptions. Chemical equilibrium is dealt with by means of the calculus and differential equations; measurement of the magnitude of the electric current, by means of infinite series; conduction of heat by the earth's crust is explained through the use of Fourier's series; thermodynamics involves determinants; and Maxwell's law of distribution of molecular velocities is discussed by means of the theories of probability and errors. Out of ninety texts, not including scientific journals, taken without selection from the shelves in the physics alcove of the University of Washington Library, less than twenty-five per cent were nonmathematical, and of these only one fourth were published during the last twenty years. A similar investigation of the standard scientific journals of physics and chemistry for the past two years revealed the fact that the nonmathematical articles not only constituted less than half the total number but at the same time occupied not more than a third of the total space. But physics and chemistry are not the only sciences progress in which depends upon mathematics. No less an astronomer than J. Herschel has said of astronomy,[9] "Admission to its sanctuary and to the

[8] J. W. Mellor, Higher Mathematics for Students of Physics and Chemistry.

[9] J. Herschel, Outlines of Astronomy, Introduction, paragraph 7.

privileges and feelings of a votary, is only to be gained by one means—sound and sufficient knowledge of mathematics, the great instrument of all exact inquiry, without which no man can ever make such advances in this or any other of the higher departments of science as can entitle him to form an independent opinion on any subject of discussion within their range." Mathematics applied to biology has in the last few years caused great progress to be made in the study of the classification and inheritance of variations. The numerous and epoch-marking investigations of Karl Pearson and C. B. Davenport are witnesses to this fact. The latter, in a small text filled with formulas whose derivation involves a knowledge of the calculus and of the theories of errors and probability, discusses such subjects as variability of the sexes and of primitive and modern races, heredity, effect of environment, racial differentiation, and variation in flowers. Nor are geologists independent of the assistance offered by mathematics. In an introductory statement to a table of hyperbolic functions published by the Smithsonian Institution,[10] we find this statement, "Whenever mechanical strains are regarded as great enough to be measured, they are most simply expressed in terms of hyperbolic functions. Hence geological deformations invariably lead to such expression, and it is for that reason that Messrs. Becker and Van Orstrand, who are in charge of the United States Geological Survey, have been led to prepare this volume.[11] "The study of hydrodynamics and of the general circulation of the atmosphere brings the meteorologist to the investigation of differential equations and of the Riemann surface." But further evidence is superfluous and would become tiresome. Enough has been said to warrant the statement that the science teacher may receive substantial benefit from mathematical training. It remains to indicate in a very general way the minimum of mathematical preparation consistent with success in science teaching.

Referring again to the facts gleaned from the physics texts previously mentioned, of the mathematical texts—as distinguished from the purely descriptive—over seventy per cent involved the calculus, differential equations, or more advanced subjects. Merely for the purpose of comparison, classifying all mathematics below the calculus as elementary, and all

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[10] Smithsonian Mathematical Tables, Hyperbolic Functions.

[11] Monthly Weather Review for 1897.

including and beyond it as advanced, the mathematical articles in several of the leading scientific journals grouped themselves as follows:

Journal.	*Date.*	*% Elem.*	*% Adv.*
Physical Review.......	July-December, 1909	40	60
Physikalische Zeitschrift...	January-June, 1908	54	46
Annalen der Psysik....................	1906	33	67
Journal de Physique..................	1909	36	64
Philosophical Magazine and Journal of Science..................	1909	22	78

While no very definite conclusions can be drawn from the figures here exhibited, since the material examined is too limited both in amount and subject-matter, it is patent that the higher mathematics figures largely in modern scientific research work and that the reader of scientific literature must have progressed beyond the elements of the calculus. The minimum of mathematical preparation for the teacher of science would seem to be, then: first, a thorough mastery of the elementary mathematics and its applications; this will train the mind to scientific modes of thought, establish habits of accuracy, and furnish the beginnings of a scientific language; second, complete courses in the calculus and differential equations both ordinary and partial, together with their applications; this will assure the possession of a finished scientific language and give a keen perception of the processes of nature; third, one or more additional courses, the nature of which will be determined largely by that particular science to which the individual is to devote his time and energy, such as, for instance, theory of functions for the physicist, and theory of errors and probability for the biologist.

This ideal is by no means difficult of accomplishment, nor is it advanced here as a new idea, but rather as a more or less accurate estimate of the present trend in scientific education.

THE PRODUCT OF OUR BOTANICAL TEACHING.[1]

By Otis W. Caldwell,
University of Chicago.

Notwithstanding the frequent assertion that teaching of botany is not what it should be, it seems safe to say that there was never a time when there was more good teaching of the subject than we have to-day. That we should have dissatisfaction at a time when so much good teaching is being done, is not at all surprising, inconsistent or undesirable. Botany itself has grown so rapidly, its call for new researches has been so insistent, its place in the applied sciences and in the affairs of men in general, has assumed such prominence and importance, its use as a means of giving a proper education in scientific thought about things that are worth knowing has been so vigorously claimed, that in consequence our attention is directed as never before to the possibilities and errors of botanical teaching.

The teaching is not poorer—we merely know more about it. Present practices are not to be generally condemned but with the increasing richness and diversity of botanical knowledge, and with better definitions of the purpose of science education, particularly education by means of botanical science, we need to consider our practices anew. If a prominent feature of reform is discontinuance of past vices, a feature of progress is discontinuance of past virtues for better and larger ones.

If the product of our botanical teaching does not meet our ideals, we should look for explanation to some or all of the factors or causes of the very complex situation which confronts us.

First, what are our ideals? What do we wish to accomplish through botanical teaching? Do we wish to use the study of botany as a means of developing on the part of the people in general a more dependable method of thinking, better reliance upon native powers of observation, experimentation and interpretation, an attitude that demands evidence before judgment may be given, or do we wish to make knowledge of plant life, its structures, processes, habits and uses, the possession of the people in general in order that they may know more, enjoy more, or may more effectively adapt plant life to their economic uses? Are we trying to use botany as a means of increasing efficiency in thought and action? Do we wish to prepare students who

[1]Reprinted from *Science*, N. S., Vol. XXXIII., No. 852, pages 639-642, April 28, 1911.

shall take up research in botany to the end that unsolved problems may have solution? Or have we any definite purpose for botanical education other than that since botany is a field which we have found most interesting we wish to "pass it on" to others?

The ends which we seek certainly should receive the careful inspection of all who are engaged in general botanical instruction. Research in botany is not the goal of general botanical education, and botany cannot claim a place in the general curriculum of the high school or college if its primary aim is to prepare students for research in botany. On the other hand, research is perhaps the most important by-product of general botanical instruction, since when general courses of instruction are efficient there develop well-grounded students who desire to become investigators in the subject.

The purpose must be more serious than to give passing enjoyment, stimulate curiosity about plants, or to minister, as early botanists sometimes said, to the emotional nature of young ladies. There is great need of development of a rigorous scientific attitude toward plant phenomena. Plants and their products are our constant companions and are related in many ways to human efficiency. If pupils learn some of the important things about plants in a way that develops care in observation, in experiment, and in proper thinking, I believe there is also secured enjoyment of plants and ability to make economic use of them. This central foundation in method and content should be best upon which to build research work. It would seem also that research would find a large number of worthy devotees if general courses of instruction were presented as broadly fundamental to the science, and more significant in practical affairs.

A second factor has to do with the quality and preparation of the students who present themselves in our college courses. From an amount of data too limited for final conclusion, it seems that most of the students who elect college courses in botany have had no botany in secondary schools. For some reasons, secondary school courses seldom lead students to take botany in college, or else college requirements prevent their doing so until they have become engrossed with other lines of work. Possibly the difficulty lies in inefficient courses or teaching in secondary schools. These courses have been accused of being too formal, too technical, too closely limited to a special field of botany, not sufficiently

full of meaning to young students. Secondary courses in botany have also been accused of being too difficult—an accusation which I think is untrue. It is not, for example, the inherent difficulty of alternation of generations, but lack of any appreciable motive for studying it, which makes it seem difficult. The structure and workings of a steam engine or an automobile are more difficult, but they are "going things"—dynamic—and students solve their mysteries. If an appreciable motive is put into secondary teaching of botany its difficulties are solvable.

Possibly some of the difficulty lies in the fact that the different sciences are incoherent and intermittent in the high schools. In a valuable recent investigation made by an eastern biologist records were collected from 276 high schools. Botany is taught in 225 of them. It is distributed in the different years of these high schools as follows: first year 76, second year 94, third year 26, fourth year 29. It is evident in so far as these and other statistics go, that something in the way of definiteness is beginning to appear as to the year in which botany is taught. But it is also to be noted that in these schools botany appears in almost every possible relation to the other sciences that are taught, and it is taught by teachers who teach almost every possible combination of subjects in the entire curriculum. The sciences need more of the same sort of consecutiveness that is found in the languages, if we are to develop more worthy educative value.

Furthermore, from the above-mentioned investigation and others, it appears that the courses in botany vary in nature from systematic botany to a study of the anatomy and cytology which deal with plant evolution. Surely the courses in secondary schools need scientific study, unless it is true that there is no part of the subject and no particular organization that is best for the education of beginners. I believe we have a right to expect that a scientific organization of the science for the secondary schools, in addition to conferring better immediate results upon pupils, will lead more of the students who have done well in science to desire to continue these studies in college. This would be of great advantage, for we need more students who early in life have begun to *think botany* and to think in the scientific method.

The nature of the preparation of our graduate students is also a factor in our product. This varies largely. In at least some of the larger universities comparatively few of the graduates come from the local undergraduate body. They have for the most part

had their training in the smaller colleges, and those who come to the university are of two classes—those who are called, and those who are sent. Some of them, through the more general courses of the smaller colleges, got their desire and enthusiasm for botanical investigation, and come to the university to continue that study. They are chiefly those who give us new botanical knowledge. Others, who have not secured suitable positions, come to the university and do graduate work as a means of securing better employment, and good botanists and good teachers sometimes develop from this group.

Another factor in the efficiency of our student product is found in the nature and appropriateness of the courses into which these students go when they come to colleges. Whether research or teaching is the end to be secured, there are needed courses in the general fundamentals of plant life and structures, and in chemistry, physics, physiography, and general physiology. Too early specialization is likely to produce a narrow research student, and to render a teacher unable to give to his students the necessary vitality in his introduction to general botany. In our revolt from the special field of systematic botany, botanists went to an extreme of even greater specialization, so that sometimes students in research in morphology are uninformed regarding the relationships of the particular plants with which they work. And so specialized are we at times that teachers in small colleges and secondary teachers who have had our so-called general courses must teach a special field of botany because they know no other. It is quite possible in some cases to go into a secondary school class in botany and by observation of the nature of the teacher's work, to determine the university in which the teacher was trained. This, of course, is not an argument against research in which we all believe most profoundly, nor against emphasis upon special lines of research in different universities, but is an argument against permitting that special research to dominate courses that presumably are for general education in botany. As Schleiden in 1849 organized the general field of botany as an inductive science, we again need for general students a presentation of the fundamentals of the science as a whole.

There are many other factors that have to do with the efficiency of the product of our botanical teaching. We need more students who in their latter college years have definite purposes in mind—as teaching, research, practice of forestry, agriculture,

etc. Possibly our teaching ought to enable them to discover purposes that will absorb them as do other college interests.

More fundamental, however, is the fact that we have been too content to assume without sufficient data, and to dictate regarding the nature of the needs of general instruction in our subject rather than to make the same sort of investigation in the field of teaching that we should make in our botanical investigation. If we can devise methods of making a scientific study of botanical education, we can improve our student-product.

FOUR MILLION ACRES SURVEYED.

During August the topographic engineers of the United States Geological Survey made field surveys of 6,517 square miles—over 4,000,000 acres—in various parts of the country, ranging from swamps to high mountain areas. The surveys comprise actual map making on the ground and the putting on the map of every natural and artificial feature in its exact relative position as it actually exists in the area surveyed.

SOME AGRICULTURAL EXPERIMENT STATION BULLETINS.

From the California station comes a 35-page bulletin on "The House Fly in Its Relation to Public Health," (bulletin 215, by William B. Herms), which appears to be quite the best thing in its way that has appeared in brief form. The several farmers' bulletins issued from Washington, are excellent; but each covers a restricted field, such as methods of prevention. The California bulletin discusses the different species of flies, follows the life history of the house fly, gives the case against it as a distributor of bacteria and its relation to particular diseases, and presents the effective methods of control. It is fully illustrated. The bibliology introduces the reader to some of the literature of the subject, the existence of which is commonly known only to professional workers.

The bulletin is a good example of real civic biology.

The New Hampshire station publishes a progress report of investigations of fruit bud formation carried on in 1908-09-10. (Bulletin 153). No conclusions are drawn at this time, but data are presented, largely in graphic form, which promise to throw much light upon the important problems connected with the productivity of apple trees and with the habit of bearing in alternate years.

Bulletin 216 of the California station reports results of experiments upon the effect of soil and climate upon composition of wheat. Soil from two other states was transported to California in sufficient quantities to allow wheat to be grown in the California climate, but in Kansas and Maryland soil. The experiments are not yet conclusive.

W. L. Eikenberry.

PHYSICAL GEOGRAPHY IN THE HIGH SCHOOL.[1]

By E. E. Ramsey,
Bloomington, Ind.

(*Continued from December issue.*)

Another group of work given is that of elementary chemical and physical experiments as illustrative or demonstrative work. This particular line is given in all reports. The study of the thermometer, of the barometer and of other meteorological instruments, experiments with the atmospheric gases and liquids are given considerable place. The sand box, sand modeling, permanent model making and relief maps are worthy of consideration.

Globe exercises and mathematical geography are given in three reports. Rivers and river action are suggested by two. Life conditions, glacial action, library work, and elementary agriculture are each given once. The item of library work is probably reserved by many of the teachers answering as belonging under a different heading. But it may belong here as well as elsewhere. Specifically directed library work should be of value in at least two ways: (1) It should serve to give a wider outlook upon the subject and a specific view upon some topics—a thing which any text-book must of necessity not do. There can be many books secured which furnish such material. (2) The inability of the average high school freshman *to read* is a widely spoken of condition, though a normal one. One thing which the high schools *are not doing* is to teach *how to read.* This is, in mathematics, in history, in English, in language and in the text phase of science, simply saying that there is failure to teach the student *how to study.* Some of the laboratory time in a science subject can be most wisely spent in directing the reading of the class.

Question 14. How much field work do you do?

The answers were tabulated in total as follows: no answer, 4; no field work, 21; very little, 9; some time, 3; as much as possible, 3; optional with students, 1; a good deal, 1; six trips per year, 4; five trips per year, 5; four trips per year, 4; three trips, 1; two trips, 4; one trip, 2. In reality this makes 50% or more of the schools reporting doing no field work.

Question 15. State the plan of your field work.

As to whether real field work is being done when a class is

[1]I desire to acknowledge the help of Dr. J. W. Beede, who has discussed with me the plan followed in the Report and who has also revised the list of questions sent out.

out on a trip is not to be decided by merely being out in the field, but by the plan which the teacher is able to formulate before entering the field. It is indeed a rare teacher who can keep a class of high school students together in the field well enough to outline a valuable impromptu piece of work. So the plan should be worked out ahead of time, put in mimeographic form and handed to each student before entering the field. The problems must be *specific;* no such directions as "study the river" or "study the valley" will lead to any observation. Specific questions relating to the river or the valley must be prepared; such as, Does the river meander? If so, give the character of each bank of the stream; give the character of the river itself on each side of the meander; where is the gorge or valley widest? Why so? In what directions is the valley enlarging? Why?

The answers to this question are disappointing in that the materials, forms and forces worked with, and not the methods of the presentation are given as answers. Field work in the biological sciences and physiography is in an undeveloped state. It was hoped to collect actual methods that would be of value. Some suggestions of this type are made: "I require rough field notes. Questions are encouraged while in the field. The field work is followed by a class exercise based upon it." Another says, "I have specific things in mind for each excursion." Discussion of the field work in recitation is given by another as a part of his plan. The making of notes and drawings (4) others consider as important. The answer is logical. Field work upon material covered by the text is planned. Question sheets are given to students and permanent notes (4) are required. Class discussion (2) follows. The use of the question sheets is suggested by four returns. This one is also worth quoting, "An outline is given the class. Discussions are carried on in the field and written accounts are handed in." The idea of carrying on class discussions in the field is an excellent one, since incorrect observations and interpretations can be settled in the presence of and by the form under consideration. This answer brings out still another valuable point, in fact, a point the most nearly fundamental of all. "The teacher must have a personal acquaintance with the forms studied, there should be a few definite things to be seen and all observation should be noted and afterwards permanently recorded." The first part of this last answer is not only a point which will save much time, but it will insure that the things can be seen.

Question 16. What idea do you have in mind in doing field work?

Twenty-five reports contained no answers to this question. Nine consider that the purpose of field work is to teach the student to observe. Another very common suggestion (9) is visualizing, substantiating and fixing textual matter. It is probable that the second function need not be brought into use often. Changes in progress in the local field (9) is unquestionably a valuable end; or rather the idea carries two valuable ends. There is no more distinctive feature of geography to-day as contrasted with geography of 30 years ago than the idea of *change*. Then the earth was felt to be relatively stable; such an error not unfrequently has crept into literature. Nowadays the idea of change has so thoroughly permeated the whole system of geography that a nomenclature heretofore used with reference to life only has been added. This nomenclature speaks of a *young* valley, an *old* volcano, a *matured* drainage system, an *active* river, an *overloaded* stream, a *drowned* valley, a *dead* river, a *rejuvated* region. All the descriptive terms have been borrowed from the biological sciences. It is important to have the student see some of these changes in progress. The study of the type forms of the local field is also valuable. There are but few fields in which some of the important general type forms cannot be found at work. Such elements as these should be studied at first hand. The next suggestion (8) is for the study and interpretation of local type forms. To create an interest in nature is given by four papers. The purpose is a worthy one but is *somewhat* indefinite. Others think of field work as the best means of getting correct ideas of forms and processes treated in the text (3). The field work guides the pupil in seeking causes and gives him the power to interpret the facts of the text (4). It gives a better conception of the laboratory work (1). It makes the science concrete (1). It gives the pupil an active interest.

Question 17. Is your time for field work limited?

The answers reveal the real situation that the high school teachers are in with respect to all kinds of field work in so far as the time element is concerned. The college and university schedules are built along different lines and the students are in school under different conditions than those surrounding high school students. The character of the afternoon schedule of the university student and the Saturday work of the high school student makes a very difficult problem for the high school.

Forty-seven schools report serious limitations on their time for field work and all others make no report. Two more high schools in large cities say that the work is impracticable because of distance and car fare. Sixty schools out of 63 do not have sufficient time at their disposal and one resolves itself, as is brought out in the answer to question 19, into a question of schedule.

Question 18. If so, how do you overcome this difficulty?

Twenty-two schools do not answer this question and nine state they do not overcome the difficulty. Ten report that they have pupils do individual work and four more report that they have individual field work but add that they require written reports on the field work. "Use the time before school and after school." (5) The plan of trading periods with other teachers who have the same section just previous to or just following the physical geography is given by five. Some schools (4) find that voluntary field work is successful. This will undoubtedly be true in the rural and township high school. Another phase of voluntary work is for the teacher to make trips with the interested students. Both these ideas have their limitations in the fact that they appeal to the students who do not need the work so much and leave the students who need awakening without its advantages. One superintendent states that he takes time for his field work at the opportune time.

Some (4) find it possible to make Saturday trips. In connection with these trips one teacher mentions the organization of a physiography club, presumably largely for the purpose of definitely organizing field work. The use of the lantern (2) would seem to warrant a wider use than it has in teaching local geography. Its use cannot replace field work entirely. However, after students have acquired some facility in the field, this method serves as an excellent review of local forms. Not all forms of geographic interest and importance are "scenery" by any means, yet some of them are. It is true, also, that real geography is not all scenery by any means. The class will usually have seen these, so that the lantern serves as a review. In lieu of all field work wherever it is entirely out of the question the lantern is certainly next in value in visualizing the text and studying forms and processes. Every geography teacher *should* be a photographer and be able to make his own lantern slides. Slides thus procured are very much less expensive and have a

much greater value in that the maker knows his subject, which fact is not always true of ready prepared sets of slides.

Question 19. What changes would you recommend in recitation, field and laboratory work in order to bring about better results in physical geography?

The answers to this question reveal, as do the answers to question 12 and 14, the pressing need for more laboratory and field work in geography, in the minds of the teachers of this subject. Sixty-one per cent (28) of the schools answering this question unite in saying that double periods for laboratory work or more time—in many instances double time is suggested and is needed. Others (4) want the subject made a full year's course, while some speak of the need of time by saying that geography "should be put on a par with physics and chemistry."

It is strange that school officials should insist that such work as geography be done without the same opportunities for work that the other sciences have. It should have such opportunities for two reasons. In the first place, since the subject is more commonly taught in the freshman year than elsewhere and since one of its purposes is the development of the method of science, it seems almost imperative that it be put on the laboratory basis—that is, on the double period plan. It is not possible to complete the subject in one semester nor in one year with 5 periods per week. The statement that the subject cannot be completed in one semester is modified in a few instances by the fact that it is sometimes followed by a semester of commercial geography. Its *breadth* requires ample time for its completion and mastery. Less formal recitation work (2) is believed to be a means of securing better work. With the expansion of laboratory work, the need for recitation, and particularly the formal type, will be greatly decreased. Better equipment for laboratories is asked for by seven reports. In view of the fact that the laboratory for geography can be equipped at less expense than that for any other science, this seems a reasonable request. The idea of combining it with elementary science is advocated by two reports. The same point has been brought out more fully in a report upon a previous question. Smaller classes are needed (2). The introduction of regional geography is given by two. The anthropological side is not insisted upon enough (2). Emphasis should be placed on local forms (2) and non-local features should be omitted (1). To the suggestion that local forms should be studied, one reported that the contour maps of the

local region should be studied in the field. The difficulty with this suggestion lies in the fact that the United States Geological Survey series of maps from this standpoint is incomplete. The wisdom of the suggestion can be easily verified wherever local maps have been issued by the Survey. Such a map is *the* one to be selected with which to begin to study contour maps. Interpretation will require a minimum of effort in the use of such maps. These further suggestions are made: more map work (1); *specifically* directed field work (1); proper manual (1); better maps (1); use of the lantern (1); development of a "thinking recitation" (1); organize grade geography concepts (1); entire work should be done in field and laboratory (1); the last suggestion seems to carry field and laboratory work too far. The answer is closely allied to the suggestion that the work be limited to local forms. While these should be emphasized, it is rare that local forms cover the field. The informational side *must* be conceded to have some place in the whole scheme of any subject. This must be omitted in too great a degree if either suggestion be carried out in its entirety.

Question 20. Do you teach the subject from the geocentric or from the anthropocentric viewpoint?

Twenty-four favor teaching the subject from the geocentric side, twenty-three from the humanistic, eight say that both should be taught as coördinate phases of the subject and several do not answer.

Question 21. What amount of time should be allotted to the following topics in a nine months' term, making a due allowance for the fact that the amounts should be modified if particularly adaptable local forms exist?

The average amount of time recommended to be spent on mathematical geography is three weeks; that on weathering is a little more than four weeks; that on rivers and river action nearly five weeks; more than two and one half weeks on glaciology; nearly three weeks on mountains; nearly three weeks on vulcanism; more than six and one-half weeks to meteorology; nearly three weeks to plant geography; two and one half weeks to animal geography; and nearly three weeks to the geography of man.

This question is meant to evaluate the various phases of the subject only. There is, however, rather too wide a range of time spent on some sections of the work. Meteorology can hardly be said to show accurate evaluation. The average amount

of time given to mountains and vulcanism is probably a little high for conditions in the states from which these answers came.

Question 22. What do you think of the value of physical geography as a high school subject to be?

The answers to this question have necessarily involved some overlapping and repetition, because of the specific character of some former questions and the general character of this one. All but four report on this point. The training of the observational powers ranks first in point of numbers (17). It is worthy of note that this value which is given greatest emphasis implies laboratory and field work for its consummation. Following the observation comes the necessary result of keen, well directed observations—reasoning (12). Seven put what amounts to the same thing in "It explains natural phenomena." Geography trains the student to think in a specific way (9). It gives a general understanding of the earth as the home of man (10). It makes broader thinkers (3). It compels reasoning from cause to effect or vice versa (5); this is done in a broader and more complete way than any other science can possibly do it, because of the composite character of the subject. Its value as an introductory science is brought out in ten reports. Local conditions are brought to the student's notice in a new way (5). Four answers mention the informational side as among its greatest values; others emphasize its value from the expression standpoint by saying that "it develops the powers of oral and written expression." It organizes and adds directly to grade work (5). Two speak of its practical character. One puts it, "Extensive (physical geography) vs. intensive (all other sciences)" and the same idea is brought out in "it synthesizes the sciences." Its adaptability renders it valuable (1). Its relation to the biological sciences and to history is given by five reports. There are reports that state that geography is not valuable as now taught; two of these specify that the subject is too abstract without field work.

One value, as it seems to the writer, has not been noted in the report. In any subject a cardinal purpose should be to develop a judgment in the subject taught. If one questions the average freshman upon some of the fundamental concepts of geography, size, direction, distance, number, etc., it will be found that he is deficient—possibly because of his age—upon these lines. The whole life is surrounded by geographic things. It is certainly fundamental in the subject then to develop a careful judgment.

Question 23. Is physical geography as well adapted as a high school subject from the standpoint of subject matter as the biological sciences or as physics or as chemistry?

The question of adaptability is always a vital one in the choice of subjects for the curriculum of any kind of school. Thirty-six schools answer yes; a few qualify the answer with such statements as, "if laboratories for physical geography were the equal of chemistry and physics laboratories." Nine answer "better," "Not as good as the biological sciences, but better than the physical science" (4). One has it that it is not so good as physics and chemistry, but better than zoölogy and botany. If field work is carried on, yes (1). Seven do not rank it as high as the other science subjects. There are no answers from four. This makes a total of 57 who, with the exceptions noted above, consider the subject within range of high school students. Many of these put their answers in a very emphatic way.

Question 24. To what extent do you use models, contour maps, and intricate apparatus in laboratory work, in demonstration work?

Many schools indicate in their reports the need of laboratory materials. It is hoped that the result of this question may be to evolve a list of laboratory supplies suited to the needs of the high school students. These are the results of the tabulation of the answers.

Wide use of contour maps	33
Wide use of models	23
Limited or no use of models	15
Limited or no use of intricate apparatus	43
Limited use of contour maps	12
Wide use of simple apparatus	59
Use of lantern slides	4
Homemade models and apparatus	5
Barograph	2
Thermograph	1
Maximum and minimum thermometers	2
No maps, models or apparatus when real form can be gotten	1
Have no apparatus	2
Much of present laboratory material is unsatisfactory	1

Reports regarding the use of specific pieces of apparatus, the barograph, thermograph, barometer, maximum and minimum thermometers, are all very complete. Some schools simply men-

tioned these to show what the character of the apparatus they use is.

Forty-five reports make definite mention of either a somewhat limited or a wide use of contour maps. In answer to another question, one teacher says that he doubts the value of contour maps as laboratory material in the hands of the student. The suggestion has already been made that wherever available the introductory interpretative study of a contour map should be based upon the local map; if not upon a local map then a map that approximates local conditions should be introduced. The map itself can never stand for laboratory work. The form behind the symbolism of the map must be insisted upon. There are no points in such maps any more difficult than the symbolism in algebra. The student must know definitely and finally that the contour line is the basis of such maps and that practically all questions from the topographic standpoint must be referred to them for answer. No involved apparatus is needed to show what the contour line is. A bucket with a hose bib set in it near the bottom, water and an irregular rock with the irregularities rounded down if possible, is much to be preferred to complicated apparatus now sold for this purpose, or to the "data" method given by some manuals. The average student has before beginning the subject a fund of observation large enough to build upon in interpreting these maps. This should be supplemented by some form of field work to clinch such interpretation. Students of average ability in the freshman year *can* interpret these maps without overdue expenditure of time and energy and without acquiring a distaste for such work. The writer has tried such a class of students on free hand modeling in clay of such sheets as the Cucamonga, Charlestown, Watkins and Watrous, asking for larger features only. In every case the pupil in one hour's time was able to translate a small but typical part of each map into a relief map. In most instances this work had been preceded by the study of not more than a half dozen maps.

It is certainly unwise to expect the development of the great breadth of content possessed by the subject—and certainly some of this breadth of content should be acquired by the student to do either the student or the subject justice—either by the text method or the field method or by a combination of them. It should be noted that a failure to secure the breadth of view loses to the student one of the cardinal values of geography.

Incidentally the loss of this point carries with it the value that the subject may have with respect to scientific training, to the humanistic side, to its basal character for history and other sciences. It seems logical then to secure this wideness of view, after the student has exhausted the possibilities of field work because of the somewhat limited character of any local field and because of untoward conditions of schedules, through the use of contour maps.

The use of models is valuable in interpretative work. They are not so amenable for use in the laboratory work by students, as are contour maps. The cost of models is great also. The making of them by the students and teacher working together is to be favored. However, one class can hardly be expected to assist with more than one or two such maps in a semester.

The failure to use intricate apparatus and the uniformity with which simple apparatus is insisted upon is commendable. The use and value of the meteorological instruments will be discussed as a separate topic.

Question 25. Do you do any elementary chemical and physical experiments for their bearing in physical geography?

Eleven schools report that no such experiments are done. Forty-one answer in the affirmative and five say that "a few" are done, making a total of forty-six schools employing such work. In view of the composite character of physiography and meteorology, it is not possible to *teach* either line of work in the freshman or sophomore year without some such work, unless there are thoroughly organized and vigorously presented elementary science courses in the grades. These experiments should be almost wholly of a qualitative character. The *how* of the thing is much more important at this age than the *how much*.

(*To be continued.*)

HARDENING PLATINUM.

Pure platinum is as soft as soft iron, and nearly all the commercial product is hardened by the addition of iridium, which is one of the congeners of platinum. It is stated that osmium, another member of this alliance of high-priced metals, has been found superior to iridium for the purpose mentioned, 2 per cent of osmium imparting as much hardness as 5 per cent of iridium and much greater elasticity. The presence of iron or copper is said to neutralize in a considerable measure the hardening effect of osmium. More than 20 per cent of the latter metal renders the platinum brittle. The alloying must be done in a deoxidizing atmosphere, as osmium is easily oxidized and the fumes are poisonous.

PROBLEM DEPARTMENT.

By E. L. Brown,

Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

259. *Proposed by R. E. Bowman, Alliance, Ohio.*

Solve:

$$\left(3-\frac{6y}{x+y}\right)^2+\left(3-\frac{6y}{x-y}\right)^2=82. \qquad (1).$$

$$xy=2. \qquad (2).$$

No solution received.

Remark by Editor. This problem appeared in the first edition of Hawkes' Advanced Algebra, Ex. 60, p. 118. In later editions equation (1) reads:

$$\left(3-\frac{6y}{x+y}\right)^2+\left(3+\frac{6y}{x-y}\right)^2=82.$$

The problem as proposed can of course be solved by eliminating either of the unknown quantities and solving the resulting equation by Horner's method. Can the problem as proposed be solved by quadratics?

260. *Proposed by A. C. Smith, Denver, Colo.*

The sum of three numbers in G. P. is 42. The difference between the squares of the first and the second is 60. What are the numbers? (Hawkes' Advanced Algebra, Ex. 36, p. 140.)

Solution by Gertrude L. Roper, Detroit, Mich., and S. F. Atwood, Dayton, Wash.

Let x=first number in series

And y=ratio

Then $x+xy+xy^2=42$

And $x^2y^2-x^2=60$.

$$\text{Hence } \frac{60}{y^2-1}=\left(\frac{42}{1+y+y^2}\right)^2$$

Or $5y^4+10y^3-132y^2+10y+152=0$. (1)

By Remainder Theorem $y-4$ is a factor.

$\therefore y=4$ and $x=2$.

Therefore the numbers are 2, 8, 32.

Remark:

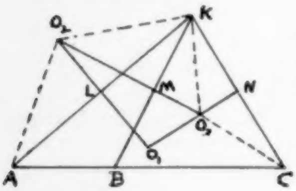
Professor T. M. Blakslee, Ames, Ia., reduced equation (1) to the form:

$$z^4+z^3-6.6z^2+.25z+1.9=0.$$

and solved ***graphically.***

Geometry.

261. *Selected.*



If A, B, C are three collinear points, and if K is any other point, prove that the circumcenters of the triangles KBC, KCA, KAB are concylic with K.

Solution by Orville Price, Denver, Colo.

Let L, M, N be the mid-points of AK, BK, CK, respectively. Let O_1 be center of circle AKC, O_2 of circle AKB, and O_3 of circle BKC.

$$\angle KBC = \angle KO_3N = 180^\circ - \angle KO_3O_1$$
$$\angle KO_2L = 180^\circ - \angle KBA = \angle KBC$$
$$\therefore\ \angle KO_2L = 180^\circ - \angle KO_3O_1$$

Since angles KO_2L and KO_3O_1 are supplementary, the quadrilateral is inscriptible.

262. *Proposed by H. E. Trefethen, Waterville, Me.*

In a quadrant a circle is inscribed and in the space included by this circle the arc of the quadrant and one of its sides a smaller circle is inscribed. Show how to construct the two circles.

Solution by the proposer.

1. Let O be the center vertex of the given quadrant and P the middle of its arc. Draw PB cutting one side of the quadrant at B and making the angle BPO=22° 30′. Draw BI parallel to the other side and cutting PO in I. I is the center of the inscribed circle. For BIO=45° =2BPI=2PBI.

Again draw ON making angle NOP=$\tan^{-1} \frac{3}{4}$ and so passing through the center of the smaller inscribed circle and through K, its point of tangency with the arc of the quadrant. See problem 257. Draw KH making angle FKH=$(\tan^{-1}7)/2$ and cutting a side of the quadrant in H. Erect HF perpendicular to this side cutting OK in F. F is the center of the required circle. For FKH=FHK=(OFH)/2 and by problem 257, OH=7FH.

263. *Proposed by Olaf K. Lie, Richmond, Mass.*

Construct a triangle, having b, c and r.

Solution by the Proposer.

We have the formulas

$\triangle = sr$, $\triangle^2 = s(s-a)(s-b)(s-c)$;

where $2s = a+b+c$.

From the given equations we have

$$s(s-a)(s-b)(s-c) = s^2r^2,$$
$$\text{or } (s-a)(s-b)(s-c) = sr^2.$$

Solving for s and reducing we have

$s^3 - 2(b+c)s^2 + [(b+c)^2 + bc + r^2]s - bc(b+c) = 0.$

Eliminating s we have

$a^3 - (b+c)a^2 + [4r^2 - (b-c)^2]a + (b+c)[4r^2 + (b-c)^2] = 0.$

As this is not a *quadratic* equation, the construction cannot in general be made by use of rule and compasses.

Miscellaneous.

264. *Suggested by Anon.*

"The most common divergences (of leaves on a stem) are the following: $\frac{1}{2}, \frac{1}{3}, \frac{2}{5}, \frac{3}{8}, \frac{5}{13}, \frac{8}{21}, \frac{13}{34}$, etc. The value of the different

fractions varies between $\frac{1}{2}$ and $\frac{1}{3}$ while always approaching a divergence angle of 137° 30′ 28″." (Strassburger, Noll, Schenck and Karsten's Botany, p 42). Prove the two statements of the second sentence.

Solution by H. E. Trefethen, Waterville, Me.

$\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, etc., are convergents to the continued fraction $\frac{1}{2} + \frac{1}{1} + \frac{1}{1} + \frac{1}{1} +$ etc. The convergents in order are alternately greater and less than the continued fraction and each convergent is nearer to the continued fraction than any preceding convergent. Hence the value of the given fractions varies between ½ and ⅓.

Put $a = \frac{1}{2} + \frac{1}{1} + \frac{1}{1} + \frac{1}{1} +$ etc., $x = \frac{1}{1} + \frac{1}{1} + \frac{1}{1} +$ etc.

Then $a = \frac{1}{2+x} = \frac{1}{2} + \frac{1}{1+x}$. Whence $x=(-1+\sqrt{5})/2$, since x must be positive; $a=(3-\sqrt{5})/2=0.3819660112\ldots$ or 137° 30′ 27.95″....

PROBLEMS FOR SOLUTION.

Algebra.

271. *Example 55, page 118, Hawkes' Advanced Algebra.*

Solve:
$$\frac{x-1}{y-1} = \frac{a-1}{b-1}, \qquad (1)$$
$$\frac{x^3-1}{y^3-1} = \frac{a^3-1}{b^3-1}. \qquad (2)$$

272. *Proposed by E. A. Cummings, Denver, Colo.*

Five balls are in a bag, and it is not known how many of these are white; two being drawn are both white. Find the probability that all are white.

Geometry.

273. *Proposed by H. H. Seidell, St. Louis, Mo.*

The chord of a segment is 10 feet and the radius of the circle is 16 feet. Find the area of the segment.

274. *Proposed by Olaf K. Lie, Richmond, Mass.*

In a sphere is inscribed a cone whose volume is one-fourth the volume of the sphere. Find the altitude and the radius of the base of the cone.

275. *Selected.*

Prove that the circumcircle of the triangle formed by any three of the four common tangents to two circles passes through the mid-point of the line joining their centers.

Trigonometry.

276. *Proposed by Franklin T. Jones, Cleveland, Ohio.*

In a right spherical triangle, the sum of two legs, a and b, is 180°, and the sum of the opposite angles A and B, is also 180°. If in such a triangle A=5°, find the lengths of the sides. (From an entrance examination paper of Harvard University).

Correction.

Page 855, problem 272, *for* proper functions *read* proper fractions.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Our readers are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

The following set of review questions has been contributed by *John C. Packard,* of *Brookline, Mass.* In the opinion of the Editor, the greatest value that can come from this department arises from the contribution of just such lists as this and the consequent exchange of ideas. What are *you* doing that gets good results?

REVIEW QUESTIONS FOR BEGINNERS' PHYSICS CLASS, OCTOBER, 1911.

1. *Water.*
   (*a*) Weight per cubic foot?
   (*b*) Pressure per foot of depth? How determined?
   (*c*) Pressure in pounds per square foot at 60 feet depth in the ocean?
   (*d*) Pressure at water tap in lecture room?
   (*e*) Instruments for measuring pressure, describe.
   (*f*) Cost of "city water" per 100 cubic feet in our town?
2. *Illuminating Gas.*
   (*a*) Pressure, how measured?
   (*b*) Pressure in our lecture room? How may this be expressed in pounds per cubic foot?
   (*c*) Volumes, how measured?
   (*d*) Cost of burning 1,250 cubic feet?
   (*e*) Meter, how read?
3. *Electricity.*
   (*a*) Pressure, how measured?
   (*b*) Pressure in our laboratory?
   (*c*) Pressure at terminals of one dry cell?
   (*d*) Rate of flow, how measured? In what terms?
   (*e*) Define watt, kilowatt, kilowatt-hour.
   (*f*) Cost of 16 K. W. H.?
   (*g*) Electricity consumed by one 16-c. p. carbon lamp?

THE SOURCES OF TUNGSTEN.

The principal sources of tungsten in the United States are two: Boulder County, Colorado, and Atolia, California. It occurs in other places which are not now productive. It occurs mainly in the mineral tungstates of iron, manganese, and calcium, the ore being concentrated and rated according to the content of tungstic acid, WO_3. Prices vary with the demand. A sufficiently recent schedule of prices in Boulder County, Colorado, grades the crude ore from $3 a ton, when it contains 1 per cent of tungstic acid, to $450 a ton of ore containing 60 per cent tungstic acid. The product is used largely as a steel alloy, while metallic tungsten is now prepared and extensively used as incandescent lamp filaments. The United States Geological Survey of Washington, D. C., will willingly supply inquirers with comprehensive reports upon the tungsten industry.

REFERENCE TO PAMPHLETS MADE EASY.

Percy E. Rowell,
Berkeley, California.

The publications of the United States Department of Agriculture are very valuable to those interested in agriculture, either as students or agriculturists, and the people at large are rapidly realizing and appreciating their usefulness. On account of the diversity of the subjects which are investigated in the various divisions of the Department of Agriculture, and which are treated in its many publications, the latter also supply much interesting material for several of the high school sciences. Since general science from its nature embraces all of the sciences in an introductory manner, it can obtain most of its supplementary material from these publications. The Department of Agriculture is very generous, especially to educational institutions, and thus it is possible for any school to build up a very satisfactory reference library at comparatively little cost.

While the publications are readily available for educational purposes, there are practical difficulties which handicap their use, and which may cause them to be worthless, both physically and educationally. Nearly all of the publications are without covers and thus they rapidly become worn out under the rough usage which they receive at the hands of the students. Being thin, the bulletins are stacked, and even if they are arranged in good order, the order becomes chaotic perhaps in an hour's use. No reference library is valuable where the information must be sought with exasperation and loss of patience. A small library, well indexed, is better than a larger one in which there is little or no order.

One system of classification is to have a large number of narrow receptacles, each capable of holding several publications of kindred subject matter, the receptacles being indexed according to a modified Dewey system. A leaflet describing this system may be obtained from the Office of Experiment Stations, Department of Agriculture, Washington, D. C. Using this system all of the publications in a given receptacle must be turned out and examined, in order to find the desired information, thereby causing a rapid physical depreciation of the pamphlets and a lessening appreciation of the information. However, if a very large number of publications are to be made handy for reference, or if a comparatively few mature students are to work with such a collection, this method has its advantages.

In my work in General Science, however, where the class is composed chiefly of ninth grade pupils, it has been found best to make reference work as easy as possible, in order to stimulate a desire for independent reading. While the method, to be described, might prove unsatisfactory for handling several hundred pamphlets, it is eminently satisfactory where there are but a few more than one hundred, which is the case in my General Science text.

The materials, necessary for all of the pamphlets which are referred to, are as follows:

Twelve sheets stencil board (hard pressed Manila, light weight) 28"x42"; 108 elastic bands of square cross section No. 18; 108 Dennison's labels No. 259.

Cut the stencil board into pieces 9⅛"x12¾". Fold each piece across its shorter diameter, six inches from one end. This allows the other side to project three-fourths of an inch. With the folded edge next to you, having the shorter side on top, paste a label on the left side of the extension. This is to be the top. Trim the two corners of the extension

similar to the corners of the label, and also trim the two ends of the fold in the same manner. This makes notches at the fold. Place the bulletin in this cover with the right side of the top next to the label. Open the cover and also open the bulletin at its middle. Then place an elastic band around the cover, and the middle of the bulletin, and push it into the notches. The bulletin is bound.

Number the labels according to the number of the bulletin. Thus: Farmers' Bulletin 28 would be F. B. 28, Office of Experiment Stations Bulletin 101 would be O. E. S. B. 101, Bureau of Soils Bulletin 73 would be B. S. B. 73, reprints from Yearbook would be R. Y., followed by the number, and Forest Service Circular 130 would be F. S. C. 130.

These bound pamphlets are to be treated as cards in a card index. A box is necessary for this purpose, and, for the hundred odd publications which are used with this book, the following dimensions should be used: Length, 20", width, 9½", depth, 5", all inside measurements. The stock should be one-half inch thick, planed on both sides, and the bottom should be set in and not nailed on the outside.

The pamphlets should be arranged according to increasing numbers in each class, that is: F. B., O. E. S. B., etc., and the classes should be separated by single sheets of cardboard, bearing a label in the middle of the top, stating the class. This cardboard should be different from the stencil board and also should be thicker. Its dimensions should be 9⅛"x7". By this method any pamphlet is immediately accessible, and, since all the references are given by number of pamphlet, and also by page number, there is no need of classification by subject matter. This is an added advantage, for the pupils will learn to classify facts for themselves, which is a long step towards education.

WHAT OUR RIVERS CARRY.

Enormous Loads of Sediments and Dissolved Chemicals—Importance of Water Investigations by United States Geological Survey.

Colorado River discharges during an average year into the Gulf of California 338,000,000 tons of mud and silt as suspended matter. In addition to this the dissolved substances in the water include 4,550,000 tons of sodium chloride, or common salt; 3,740,000 tons of Glauber's salts; 4,000,000 tons of lime; 2,400,000 tons of gypsum; and 4,800,000 tons of Epsom salts. In spite of all this dissolved material the Colorado at its mouth is not considered to be a stream of unusually high mineralization for that region of the country. The reason is that the river also carries so enormous an amount of water that the dissolved salts constitute a comparatively small proportion of the total discharge. Other streams in the country contain dissolved salts in greater concentration—for example, the Elm Fork of Red River, in Oklahoma, discharges nearly 1,300,000 tons of common salt annually. Although this amount is not so great as that discharged by the Colorado, it is much greater in proportion to the size of the area drained. The discharge of salt from the Colorado is equal to twenty tons annually to each square mile drained by the river, but the salt in Elm Fork of Red River is equal to 1,680 tons per square mile of area drained. The same river discharges annually 177,000 tons of magnesium chloride, 168,000 tons of Epsom salts, 690,000 tons of gypsum, and 54,000 tons of lime. These quantities, too, are considerably greater than those carried in the Colorado in proportion to the size of the drainage area.

ARTICLES IN CURRENT PERIODICALS.

American Forestry for November: "A Fire Protection Plan in the Southern Appalachians," W. H. Weber (eight illustrations); "Reforestation on the Pike National Forest," C. W. Fitzgerald (five illustrations); "Fire Protection in the National Forests," Earle H. Clapp; "The Minnesota Forest Experiment Station," Dillon P. Tierney, (six illustrations); "The Water Oak as a Shade Tree," C. D. Mell, (one illustration); "Co-operation in Forest Protection," E. T. Allen; "Timberland Protective Associations," E. A. Sterling; "Forest Schools of the United States, VI. University of Georgia," (four illustrations); "Collecting Lodgepole Pine Seed," A. M. Cook; "Forest Schools of the United States, VII. Biltmore Forest School," (four illustrations).

Catholic Educational Review for November: "Religion in Education," Edward A. Pace; "Fatigue in Teachers," Brother Valentine; "The Education of the Priest of To-day," J. A. McClorey; "The Educational Work of the New York Sisters of Charity," A Sister of Charity; "Military Training for Adolescents," John J. Tracy; "Education of the Laity in the Middle Ages," Patrick J. McCormick.

Educational Psychology for November: "Problems in the Psychology of Vocational Education," David Snedden; "The Bearing of Heredity upon Educational Problems," Henry H. Goddard; "Mental Development and the Measurement of the Level of Intelligence," Sante de Sanctis.

Education for November: "Sociological Basis of the Science Education," Charles A. Ellwood; "Observance of Historic Days at School," Horace G. Brown; "The New England Town School," Alden H. Abbott; "Cultural Value of Music," Helen E. Sellea.

Mathematical Gazette for October: "The Theory of Order, as Defined by Boundaries," E. T. Dixon; "Proof by Recurrence," Sidney Lupton; "Appreciative Remarks on the Theory of Groups," Professor G. A. Miller.

Physical Review for November: "An Absolute Determination of the Minimum Ionizing Energy of an Electron, and the Application of the Theory of Ionization by Collision to Mixtures of Gases," Edwin S. Bishop; "Studies in Luminescence. XVI. The Fluorescence and Absorption of Certain Uranyl Salts," Edw. L. Nichols and Ernest Merritt; "Determination of Peltier Electromotive Force for Several Metals by Compensation Methods," A. E. Caswell; "The Recovery of the Giltay Selenium Cell and the Nature of Light Action in Selenium," F. C. Brown; "Thermal Conductivity at High Temperatures," M. F. Angell; "On the Fatigue of Metals Subjected to Roentgen Radiation, in the Presence of Chemically Active Gases," Edward G. Rieman; "New Records of Sound Waves from a Vibrating Flame," Joseph G. Brown.

Popular Astronomy for December: "Star Colors and a Method of Verifying Them," C. H. Gingrich; "Star-Streams and Their Distribution," Hector Macpherson; "The Isolation of an Ion," William J. Humphreys; "The Evolution of the Starry Heavens," T. J. J. See; "Mas as Seen with an 11-Inch Reflector," Latimer J. Wilson; "The Perseids 1911," R. M. Dole; "A Modern Look at the Universe," Henry Olerich.

Psychological Clinic for October: "Retardation in the Schools of Palo Alto, California. A Study of Pedagogical Life Histories," I. D. Payne; "Retardation in the Schools of Stockton, California. A Study of 300 Pedagogical Life Histories," J. O. Gossett, Leland Stanford Junior University; "The Renaissance of Bob," Charles K. Taylor, Philadelphia, Pa. For November: "Congenital Aphasia," Clara Harrison Town, Ph.D., Resident Psychologist, Lincoln State School and Colony, Lincoln, Ill.; "A Speech Defect Case Treated at Columbia University," Alice C. Hinckley; "The Binet-Simon Measuring Scale for Intelligence: Some Criticisms and Suggestions," Leonard P. Ayres, Ph.D.

School World for November: "The Teacher of the Adolescent," A. J. Pressland; "An Experiment in Elementary Woodwork, I.," T. S. Usher-

wood (illustrated); "The Royal Dockyard Schools," Thomas Dawe; "On the Training of Boy Artificers for the Royal Navy," W. H. T. Pain; "The Teaching of Mathematics in the United Kingdom," J. B. Dale; "The School Garden as a Means of Education," Alex. Logan; "Secondary Schools and Free Secondary Education," J. W. Monkman.

Unterrichtsblätter für Mathematik und Naturwissenschaften, No. 7.: "Die Behandlung des Planktons im Schulunterricht," Prof. Dr. R. v. Hanstein; "Der heutige Stand der Lehre vom Lichtwechsel der Fixsterne," Prof. Dr. J. Plassmann; "Ueber das virtuelle Bild eines unter Wasser befindlichen Punktes," Dr. H. Wieleitner.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht for November: "Ebene und sphärische Trigonometrie auf ganz neuer Grundlage," Ernest von Szücs; "Beweis des Tangentialsatzes mittels der Pfielpunktssehne," H. Pfaff; "Schriften des Deutschen Ausschusses für den Mathematischen und naturwissenschaftlichen Unterricht," W. Lietzmann; "Zur Geometrographie," edited by K. Hagge.

According to the reports of the United States Geological Survey, there are a number of anthracite coal beds in Colorado, New Mexico, Montana, and Washington, besides the great anthracite deposits in Pennsylvania.

NORTH AMERICA GEOLOGY.

New Bibliography Issued by United States Geological Survey.

The United States Geological Survey has just issued as Bulletin 495 its Bibliography of North American geology for 1910 by J. M. Nickles. It covers publications bearing on the geology (including the paleontology, petrology and mineralogy) of North America and adjoining islands; also Panama and Hawaii. This bulletin is one number of a series of bibliographies, the preceding number being Bulletin 444, which is a bibliography of the geologic publications of 1909. A plan of cross references is used by which the reader can readily ascertain all the papers which have been published on any particular subject or area, or by any author. A copy of the bulletin may be obtained by applying to the Director of the Geological Survey.

INTERNATIONAL CONGRESS OF MATHEMATICIANS.

The organizing committee of the fifth International Congress of Mathematicians, to be held at Cambridge, England, August 22-28, 1912, has issued a circular giving the following items of information:

"Special arrangements will be made for the consideration of the reports of the international committee appointed at the congress in Rome to inquire into the teaching of mathematics.

"The committee has commenced to organize a series of lectures which shall give some idea of the present state and progress of the principal branches of mathematics, including its applications. The speakers already chosen are E. Borel, E. W. Brown, A. Kneser, E. G. H. Landau, Sir J. Larmor, and Sir W. White. Their subjects will be announced later.

"The congress will be divided into four sections: I, Arithmetic, Algebra, Analysis; II, Geometry; III, Applications; IV, Philosophical Questions."

"EQUALS."

BY MAIRE DOLORI.
Boston.

This note is a response to the invitation on page 717 of the November, 1911 number of SCHOOL SCIENCE AND MATHEMATICS to teachers to give some explanation of what is meant by the term, "equal."

The best test of one's comprehension of the things he is dealing with is not verbal definition, but *the way he acts in their presence.* Thus, one who puts sugar in his tea and salt on his celery has the necessary and sufficient knowledge of sugar and salt for the purposes of his luncheon, though he could not put into words his concept of either.

In much the same way, a student who freely *interchanges* "equals" in his mathematical proceedings as convenience dictates, has acquired the necessary and sufficient knowledge of their nature. Things are equal if either can be substituted for the other without change in either, and without change in any whole of which either may be a part; and conversely. This, to be sure, is very like saying things are the same when they are not different. But such definitions of undefinable things do sometimes help.

One who is employing equals properly knows that the term when applied to complex entities requires a phrase, either expressed or understood, to define its application. Thus, sects may be equal, unqualifiedly equal, because a sect possesses but one *trait,* the irreducible and undefinable something by dint of which it is a sect. But polygons may be equal in form or in area, or in both. Congruent polygons are equal in both form and area. A ten dollar bill and ten silver dollars are equal in purchasing power, but not in convenience for a given purpose.

This sharply delineated notion of equals is secured for students, not by words but by experience, or, as I should prefer to say, by *contacts.* The axiom in question, "If equals be subtracted from equals," etc., is most convenient and harmless. (I think it is harmless—and yet, I wonder.) That teachers and students might be at a loss, if challenged, to justify it in words, hardly seems sufficient reason to deprive them of its use.

In addition, I should like to suggest the duty that has arisen for teachers of geometry to make plain the unreliability of all knowledge that is the product of purely deductive reasoning *and of nothing else.*

Since with nothing assumed, nothing can be proved, and the assumptions are the "unverifiable hypotheses," it follows that for many of the elaborately demonstrated conclusions of Euclidean geometry we have no more guarantee of external actuality than if the same conclusions had been reached directly by observation and measurement. The investigations into its foundations show that geometry no more than other subjects can claim absolute certainty, and it would seem that it was time this later aspect should be made clearer in the schoolroom.

CUBA FIFTH LARGEST IRON-ORE PRODUCER.

The shipments of Cuban iron ores, according to statistics collected by the United States Geological Survey, show the record-breaking output for 1910 of 1,417,914 long tons, as against 930,446 tons for 1909, the greatest previous production. In 1900 the production was 446,872 tons. The ores are obtained from deposits near Santiago. Cuba is now the fifth largest producer of iron ore in the world, being exceeded only by the United States, Germany, the United Kingdom and France.

NOTE TO "GENETIC INSTRUCTION IN GEOMETRY."

T. M. Blakslee, *Ames, Iowa.*

"Given—The square A; the lines *m* and *n*. Required—Find a square S such that S:A=*m*:*n*."

Teacher. What two squares have we proved to have the same ratio as two lines?

Student. The squares on the sides of a right triangle have the same ratio as the adjacent segments of the hypotenuse formed by a perpendicular to it from the vertex of the right angle.

Teacher. If the hypotenuse move parallel to its original position, what can you say of the ratio of the segments formed by the rays of the sides and the perpendicular?

Student. The ratio is constant.

Teacher. If this ratio is m:n, how would you find the side *s* of S?

Student. I would lay off the side adjacent to *n* equal to *a*, the side of A, then that adjacent to *m* would be *s*.

Teacher. How would you have the ratio *m*:*n* in one case?

Student. On $m+n$ as a diameter I would construct a semi-circle. At the join of *m* and *n* I would erect a perpendicular to the diameter, cutting the semi-circle at C. I would join C with the ends of the diameter. If any parallel to the diameter be cut by the three rays concurrent at C, forming the segments m' and n'; $m':n'=m:n$.

Professor Hart's statement: "There is little left but to study it, understand it, and memorize it," while true of the solution given by him and found in most texts, is, I trust, not true of this.

CALIBRATING TUBES BY ELECTRIC RESISTANCE MEASUREMENT.

The measurement of resistance of a mercury column has been employed by T. R. Merton to calibrate capillary tubes, always a troublesome proceeding when done by measuring the change in length of a pellet of mercury. The English periodical, *Knowledge,* describes Mr. Merton's method as follows: The ends of the capillary tube communicate with two mercury cups which are connected to one arm of a Wheatstone's bridge. The mean radius *r* is given by $r^2 = \frac{1+2dr}{\pi\kappa f}$ where *l* is the length of the capillary, *f* the found resistance, and *d* a correction for the stream lines at the ends of the capillary, κ the specific conductivity of mercury. It has occurred to the writer that measurements of volume in gas burrettes might be made by inserting an iron resistance wire down the burrette inside so that the mercury uncovers more or less of the wire as it is raised or lowered, the change in resistance of the wire being accurately measured.

GREATEST IRON PRODUCING REGION IN WORLD

The Mesabi Iron Range in Minnesota produced in 1910, according to the United States Geological Survey, 53¾ per cent of the entire iron-ore production of the United States. The Lake Superior district, including Minnesota, Michigan and Wisconsin, produced 81½ per cent of our total iron-ore production. Figures from other countries are not yet available for 1910, but this is probably a greater production than the entire year's output for any foreign country.

WISCONSIN ASSOCIATION OF MATHEMATICS TEACHERS.

The teachers of mathematics present at the meeting of the Mathematics Conference of the Wisconsin Teachers' Association in Milwaukee on November 10, effected a permanent organization under the name The Wisconsin Association of Mathematics Teachers. A constitution which had been approved by the officers of the general organization was adopted. Organization was deemed desirable as a means of carrying through from year to year in the programs some definite ideas and as a means of extending further the field of usefulness of the body. All teachers of mathematics in the schools and colleges of the state and all principals of secondary and higher schools are eligible for membership. The following officers were elected for the ensuing year:

President—Mr. Henry Ericson, Milwaukee.
Vice-President—Miss Mary C. Nye, Superior.
Secretary-Treasurer—Prof. W. W. Hart, Madison.
Chairman Executive Committee—Prof. J. V. Collins, Stevens Point.

MEETING OF THE TOLEDO CENTER.

On October 27, at the Central High School, Toledo, Ohio, was held the fall meeting of the Toledo Center of the Central Association of Science and Mathematics Teachers. The attendance was much larger than that at the meeting last spring and the interest was proportionately greater. It was an extremely helpful meeting. A number of new names were added to the roll of membership of the association.

E. L. Mosely read a suggestive paper on "Some Ways of Teaching Practical Hygiene." Mr. W. P. Holt, of Toledo High School, gave a stimulating talk on "Illustrative Material in Physical Geography." The "Round Table Discussions," presided over by A. W. Stewart, of Toledo High School, extended over a period of two hours because of the unusual interest that was aroused by the questions submitted. Some of them were:

Educational Leaks—How Accounted for, How Remedied.
When and to What Extent Should Originals be Introduced into Geometry?
Definitions.
The Syllabus Method of Teaching.
The Unification of Elementary Mathematics.
Present Trend of Mathematics Judging from Text-books.
The First Twenty Lessons of Geometry.

M. R. Van Cleve,
Secretary-Treasurer.

BOLIVIAN TIN.

Bolivia, South America, is the second tin-producing country in the world, being only surpassed by the Straits Settlements. Tin is found principally in the higher peaks of the Cordillera Real, overlooking the basin of the Amazon. The ore averages 5 to 10 per cent. High grade stream tin is also found. In most operations the ore is merely crushed and washed, and concentrates of 55 or 65 per cent tin are exported. Gold, silver, copper, tungsten and petroleum also occur in this country.

ELEVENTH ANNUAL MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The eleventh annual meeting of the Central Association of Science and Mathematics Teachers was held at Lewis Institute, Chicago, Dec. 1 and 2, 1911.

The program was good, including, besides addresses and reports at the general sessions, many very valuable papers and discussions of reports in the meetings of the five sections of the Association.

The increasing influence of the Central Association in the teaching of science and mathematics in the central states was manifested by the unusually large attendance at the meeting and interest in the discussions, and also by the large number of applications for membership in the Association received at the time of the meeting. It is gratifying to note that these new members are pretty uniformly distributed over a wide range of territory, including all of the central and some of the western states.

The first general session was held Friday morning, Dec. 1, in the Auditorium of Lewis Institute, and was presided over by President Herbert E. Cobb. The address of welcome was delivered by Professor P. B. Woodworth of Lewis Institute. The response in behalf of the Association was delivered by A. A. Upham, State Normal School, Whitewater, Wis. At this session the main address was delivered by Dr. Charles H. Judd, University of Chicago, on "The Mission of Science in Secondary Schools." Following Dr. Judd's address, the report of the committee continued from last year on "Coöperative Experiments in Teaching Science" was presented by the chairman, Dr. C. R. Mann, University of Chicago. The committee was not discharged, and it is presumed that it will continue its investigation for another year.

Friday afternoon was devoted to meetings of the five sections of the Association—Biology, Chemistry, Earth Science, Physics, and Mathematics—to the inspection of exhibits of science apparatus by a large number of manufacturing firms, to the facilities for the teaching of practical correlated mathematics at Lewis Institute, and to an informal reception.

The annual dinner was held at 5:45 p. m. in the lunch room of Lewis Institute. At the dinner Dr. O. W. Caldwell, of the University of Chicago, led in a discussion of college entrance requirements, in which the new plans adopted recently by some of the larger universities and recommended in the report of the American Federation of Teachers of the Mathematical and the Natural Sciences were explained and discussed.

The address Friday evening was delivered by Dr. W. A. Evans, formerly Health Commissioner of the City of Chicago, on school ventilation and its bearing on pupil efficiency. The address was an interesting, logical, and lucid exposition of the problem.

The session Saturday morning, Dec. 2, was given over to a business meeting, followed by meetings of each of the sections.

Full accounts, or abstracts, of all addresses, reports, and discussions, before the general meetings and before each of the sections will be printed in the annual volume of Proceedings. It is expected that the volume of Proceedings will be printed and ready for distribution in a few weeks.

At the business meeting Saturday morning the auditing committee reported that the accounts of the secretary-treasurer were found correct. The Treasurer's and Secretary's annual reports were then

presented and adopted. These reports will be found printed elsewhere.

The resignation of James F. Millis from the office of Secretary-Treasurer, because of pressure of other duties, was accepted, and a successor elected to fill out the unexpired term.

A committee was appointed to consider changes in the constitution of the Association, and to prepare amendments to be acted upon at the next annual meeting.

Urgent invitations were extended to the Association to hold its next annual meeting in Des Moines, Iowa, in Milwaukee, Wis., and also at Chicago University. The matter of determining the next meeting place was left in the hands of the Executive Committee, with power to act.

The resolutions relating to college entrance requirements, formulated by the American Federation of Teachers of the Mathematical and the Natural Sciences, were adopted by the Association. These were printed in School Science and Mathematics, Vol. II, 1911.

Dr. C. R. Mann was appointed delegate from the Central Association to the meeting in Washington, D. C., of the American Federation of Teachers of the Mathematical and the Natural Sciences, with power to appoint other delegates.

The following resolutions were adopted by the Association:

Resolved, first, that the Association tender a vote of thanks to the director, trustees, and faculty of Lewis Institute for the hospitality accorded in the use of the building and for numerous courtesies shown by teachers and pupils of the Institute.

Resolved, second, that the Association express its thanks to the President, the Secretary-Treasurer, and the local committee for their thoughtful care in making complete and detailed provision for the needs of the meeting.

Resolved, third, that the Association express its appreciation of the timely, instructive, and interesting addresses given at the general sessions by Professor Charles H. Judd and by Dr. W. A. Evans.

Resolved, fourth, that the Association hereby record its gratitude to the retiring secretary-treasurer, Mr. James F. Millis, for the energetic, able, and efficient manner in which he has discharged the duties of office during the two years of his incumbency; and that it further recognize that his careful and systematic work has been a source of great strength to the Association.

Resolved, fifth, that the Association heartily indorse the aggressive policy of the President and Executive Committee as shown by the program, in pushing forward to the conquest of vital problems in mathematics and science teaching, with a view to the betterment of the schools of the present day and of the future.

James H. Smith,
Charles W. Newhall,
William P. Holt,
Committee.

The following officers were elected for the ensuing year: President, Herbert E. Cobb, Lewis Institute, Chicago; Secretary-Treasurer, C. E. Spicer, Township High School, Joliet, Ill.; Assistant Secretary-Treasurer, F. C. Donecker, Crane Technical High School, Chicago.

The chairmen of the different sections elected are as follows: Biology, Fred W. Werner, North Division High School, Milwaukee, Wis.; Chemistry, J. W. Shepherd, Chicago Normal School, Chicago; Earth Science, G. W. Mansfield, Northwestern University, Evanston, Ill.;

Mathematics, Ira S. Condit, State Teachers College, Cedar Falls, Iowa; Physics, E. E. Burns, Medill High School, Chicago.

JAMES F. MILLIS, *Secretary.*

TREASURER'S REPORT

For the Year Ending November 29, 1911.

RECEIPTS

Balance shown by last report	$ 267.90
Sale tickets for 1910 dinner	96.00
Dues 331 members at $2.50	827.50
Dues 83 members at $2.00	166.00
Dues 10 members at $1.00	10.00
Dues 14 members at 50c	7.00
Advertisements in 1910 program	251.00
Advertisements in 1911 program	148.00
Display space	5.00
2 copies Correlation Report at 25c	.50
6 copies 1908 Proceedings at 50c	3.00
2 copies 1909 Proceedings at 50c	1.00
2 copies 1910 Proceedings at 50c	1.00
Refund from Jennings & Graham, printers	1.00
Total receipts	$1,784.90

EXPENDITURES

Subscriptions to SCHOOL SCIENCE AND MATHEMATICS	$ 583.00
Printing and distributing 3750 programs 1910 meetings	292.74
Printing and distributing 1 M cop. 1910 Proceedings	241.44
160 dinners at 1910 meeting	80.00
Traveling and hotel for Dr. Wiley at 1910 meeting	35.00
Dues to National Federation of Teachers of the Mathematical and the Natural Sciences, at 10c per member	48.80
Postage in office of Secretary-Treasurer	31.50
Compensation to J. F. Millis, Sec-Treas., by Ex. Comm.	25.00
Premium on Treasurer's bond for $1,000	10.00
Printing and distributing 3500 letter heads	12.94
Printing receipts, reply postals, bill heads, envelopes, filing cards, and application blanks	31.80
V. D. Hawkins, cards to Ohio teachers for 1910 meeting	14.10
Expenses for check room boys, printing dinner tickets, etc., at 1910 meeting	5.50
Freight on maps to 1910 meeting	1.89
Stenographer at 1910 meeting	10.00
Expenses Chairman of Publication Committee	3.95
400 reprints of Report on Fundamentals	7.50
Reprints of Tower's, Miller's, and Holt's reports	8.25
Expenses of President Smith for postage and telephoning	5.45
Expenses of Earth Science Section	2.95
Expenses of Biology Section	1.10
Expenses of Chemistry Section	.65
Total Expenditures	$1,453.56
Balance cash on hand	331.34
	$1,784.90

JAMES F. MILLIS, *Treasurer.*

MEMBERSHIP REPORT.

For the Year Ending November 29, 1911

Paid up membership, Nov. 23, 1910	488
Honorary membership, Nov. 23, 1910	4
Total membership, Nov. 23, 1910	492
Delinquent, but left on list as per constitution	83
Total names on list, Nov. 23, 1910	575
New members added during year	117
	692
Resigned, deceased, or dropped for delinquency	96
Total names on list, Nov. 29, 1911	596
Paid up membership, Nov. 29, 1911	486
Honorary membership, Nov. 29, 1911	7
Delinquent, but kept on list as per constitution	103

JAMES F. MILLIS, *Secretary.*

MINUTES OF CHEMISTRY SECTION.

Meeting called to order by Chairman Mr. F. B. Wade at 10:20 a. m. Report of nominating committee, given by Mr. Wirick, the Chairman. Chairman, John W. Shepherd, Chicago Normal School; Vice-Chairman, C. B. Curtis, Central High School, St. Louis, Mo.; Secretary, Leon D. Judd, Lockport, Ill.

Moved that the Secretary cast ballot for the persons named. Carried. Secretary cast the ballot. Paper by Dr. W. R. Smith on Night School Work in Chemistry.

Discussion participated in by Dr. A. L. Smith and Professor W. C. Hawthorne.

Second paper on "The Needs of the Community in Chemical Education as Seen in Y. M. C. A. Educational Work," was given by Mr. F. B. Emery, Chicago Central Y. M. C. A., who took the place of Mr. C. L. Ward of the same school. Discussed by W. R. Smith and C. M. Wirick. 16 in attendance.

Section adjourned, 11:30 a. m.

JOHN C. HESSLER, *Secretary Pro Tem.*

MINUTES OF THE MATHEMATICS SECTION.

The Mathematics Section held two meetings at Lewis Institute, Friday and Saturday, December 1 and 2, 1911.

Friday afternoon session.—In the absence of the chairman, Mr. R. L. Short, Mr. Ira J. Condit, the vice-chairman, presided.

The secretary read a letter from Mr. Short explaining his absence.

A nominating committee was appointed as follows: Mr. W. Lee Jordan of Des Moines, Ia., chairman; Miss Esther Houser of Troy, Ohio; and Mr. C. A. Petterson of Chicago.

The Report of Committee on Results, given by C. E. Comstock, of Peoria, Ill.. Mr. Comstock urged the necessity of scientific spirit in daily work and scientific methods of testing the results. Two aspects of testing:

First: A teacher should have some means of ascertaining the extent of acquired knowledge or power.

Second: Efficiency of a given method should be judged by comparison of results of different methods.

Under the first aspect was a consideration of the following aims for mathematics teaching:

Knowledge of the facts of Mathematics.

Acquisition of tools for future use.

Clear and concise expression of thought.

Clear perception of logic of relations.

Meaning of laws and operations in Algebra and of a proof in Geometry.

To fix power and habit of testing one's own work.

Ability to observe and to generalize, etc.

Some of the broader, more neglected aims are: Habits of study, of persistance, concentration, orderliness, of will and control; discovery of special talents; encouraging originality and initiative.

Second Aspect: Methods of testing results. Following the suggestions of Professor Thorndike, some ideas for scientifically constructed examinations were given; but a test should be on only one thing at a time, as memory, speed, use of best methods, accuracy, general information.

$$\text{Efficiency} = \frac{\textit{attainment}}{\textit{time}}$$

Instead of ineffective discussion of many topics in mathematics, it is suggested that tests be made in an impartial scientific way, and a call is made for teachers willing to coöperate in this work.

Discussion of Report on Testing Results, by Charles Otterman, of Cincinnati, Ohio. In this discussion, Mr. Otterman brings out the idea that scientific testing requires an impartial mind measuring according to fixed standards. The wholly impartial attitude of mind will always be the ideal toward which a teacher should strive, but which no one will probably ever reach.

He shows also that the standards fixed by one teacher will vary from time to time; hence the best testing will be according to standards fixed, not by one's own experience, but by the experience of many.

In addition to the tests given in the report, several others in algebraic manipulations were given.

The Applications of Mathematics to Problems of the Shop, by Kenneth G. Smith of the University of Wisconsin.

In this excellent paper, Professor Smith made it clear that he was discussing "Applied Shop" rather than "Applied Mathematics," from the standpoint of a teacher of apprentice boys and shop men in "Continuation Schools."

The shop man will learn or accept only that mathematics for which he sees his immediate need. He gets his application first and his principles afterwards. This is the essential difference between mathematics in a technical high school and the teaching of this subject to boys already employed in shops, who have a half-day per week or less to study.

Principles in selecting and presenting shop problems:

1. They must come from the shop. Good mathematics problems are not necessarily good shop problems.
2. They should be stated in shop terms.
3. Data should be given in accordance with shop usage and the results obtained should represent good practice.
4. Problems should not be made unnecessarily complicated.
5. Do not confuse shop problems with problems of design.
6. Use the actual thing, when possible; if impossible, use sketches.
7. Use good shop sense in accuracy of measurement.

8. Take time to explain mechanical whys and wherefores, but not the mathematical whys, unless a boy is particularly interested in this subject.

On charts, Professor Smith outlined some shop topics especially applicable to the teaching of certain subjects in mathematics.

I. Common fractions:
  1. Measuring scale.
  2. Lengths of bolts and studs.
  3. Cutting from bar stock.
  4. Over-all dimensions.
  5. Omitted dimensions.

II. Decimal fractions:
  1. Micrometer.
  2. Decimal equivalents.
  3. Speeds, cuts, feeds, etc.

III. Percentage:
  1. Composition of alloys and various kinds of steel.
  2. Shop pay roll.
  3. Wages.

IV. Areas and volumes:
  1. Circumference and areas of circles.
  2. Areas of rectangle, hexagon, octagon, triangle, and pentagon.
  3. Volumes and weights of bar stock.
  4. Contents of tanks.

V. Ratio and Proportion:
  1. Speeds, pulleys, and gears.

VI. Handling of symbols, equations and formulae is necessary; also in Trigonometry, functions of angles and solution of triangles.

"The Significance of the Real Problem in Secondary Mathematics," was presented in a scholarly paper by Charles W. Newhall of Faribault, Minn. He showed how the very ancient problem of logical vs. practical mathematics had been discussed century after century by extremists on both sides; but the present tendency is toward a more conservative position, the finding of the proper balance between the cultural and the disciplinary values of mathematics, on the one hand, and the value of its practical applications on the other.

The reports of such committees as the one on College Entrance Requirements, the National Committee on Geometry Syllabus, and the Committee on Algebra Syllabus of the Middle States, all corroborate this view. Opinions of some of the leaders of mathematical thought were cited, showing:

First. That a uniform course in secondary mathematics is desirable in all our schools except those of a special class. The consensus of opinion seems to be that such a course should teach Algebra and Geometry for their own sake and as connected logical systems, but with a recognition of the practical value of their study.

Second. That the real problem has an important place in such a course. It should not be the underlying basis of mathematical instruction, nor its end or aim.

Miss Cleo Murtland of Wooster, Mass., was unable to be present to give her paper on "Problems for Girls."

Dr. H. R. Hedrick of the University of Missouri gave his discussion of the Report on Notation at this session. His suggestions are:

1. That notation should be as uniform as is consistent with proper teaching throughout the entire curriculum.

2. That changes in notation should be made slowly.
3. That useless duplications should be avoided.
4. That colloquial phrases be recognized sparingly.
5. That suggestive notation be given the preference.
6. All definitions should be so worded that they may be capable of continuous development.

About 100 were present at the Friday afternoon session.

The assessment levied amounted to $17.70.

Saturday Morning Session

The Report of the Committee on Uniform Notation, continued from 1910, was given by L. P. Jocelyn of Ann Arbor, Mich.

The committee recommends the series of digits be 0, 1,—9; not 1,—9, 0; that the symbol 0 be read zero; that decimal fractions be so called, not decimals; that in reading numbers "and" should not be used except at the decimal point; that in the four fundamental operations, the operator comes after the operand; that proportions be written as fractional equations.

The advisability of considering all fundamental operations as always performed on abstract numbers is discussed. The very careful reading of exponents and the elimination of obsolete symbols and terms are strongly urged.

Professor George R. Twiss of Ohio State University discussed the report from the Physics standpoint. He showed how many of the recommendations of this report have sound psychological foundation; especially the suggestion concerning the fundamental operations always being with abstract numbers.

He added some recommendations concerning uniform use and interpretation of certain terms and formulae in physics, and an agreement on single letters to represent each physical quantity, in both elementary and advanced physics.

He cautioned, however, that our decisions should not be so fixed and final that they stand in the way of further progress.

The last paper presented was one on "Correlation," by Miss Edith Long of Lincoln, Nebraska. At her own request, this paper will not be published.

Miss Long gave to each one present a synopsis of the "Course in Correlated Mathematics," which is being used in the Lincoln High School. This aims to fuse completely the two subjects of Algebra and Geometry.

In the discussion, it was brought out that in Lincoln and in Ann Arbor there is no mathematics in the first year, but a general science course is substituted.

The Report on Notation was not accepted, for the section felt the need of further discussion before taking any action. It was moved by Mr. Newhall that the Committee be continued to consider uniform notation in Geometry, Trigonometry, and Advanced Algebra, also. The motion was seconded by Dr. Slaught. Mr. Petterson suggested that printed copies be sent to members one month in advance of the meeting. The suggestion was accepted and the motion was carried.

On a motion by Mr. Jocelyn the Committee on Results was continued with the suggestion that more experiments that can be used, be incorporated in the report.

The report of the nominating committee was as follows:

For Chairman, Mr. Ira Condit, State Teachers College, Cedar Falls, Iowa; for Vice-Chairman, Mr. Charles W. Newhall, Shattuck School,

Faribault, Minn.; for Secretary, Miss Marie Gugle, Central High School, Toledo, Ohio.

On a motion by Mr. Hart the chairman of the committee cast the ballot for the above officers.

About 70 were present at the Saturday morning session.

Copies of the reports given may be had by applying to the chairman or the secretary.

E. MARIE GUGLE, *Secretary.*

Minutes of the Physics Section of the Central Association of Science and Mathematics.

The first session of the Physics Section was held in the Auditorium of Lewis Institute on Friday afternoon, December 1.

The first number of the program was in joint session with the Chemistry Section. The speaker, introduced by Chairman Frank B. Wade of the Chemistry Section, was Mr. L. A. Touzalin, assistant chief chemist of the Illinois Steel Works. His subject, "The Electric Furnace for Steel," was illustrated by lantern slides which showed characteristic views of the steel industry, from the ore mines in Minnesota, to the devices for refining and perfecting the steel, the latest example of which is the electric furnace. In the minutes of the Chemistry Section will be found an account of this important modern device. Chairman H. L. Terry then took charge of the program for the Physics Section, the Chemistry Section retiring. The chair appointed as a nominating committee: Mr. A. A. Upham, of Whitewater, Wis.; Mr. John P. Drake, Macomb, Ill., and Mr. F. R. Nichols, of Chicago.

After a brief historical review of the several "New Movements" in the teaching of high school physics by the chairman, a paper upon "The Results of New Movement in the Teaching of Physics" was read by Mr. G. A. Works, of Madison, Wis. This interesting and suggestive paper is printed in full in the Proceedings. In it is brought out the fact that the "New Movement" has caused teachers to test the efficiency of their methods and work, and has led to various educational experiments which aim at more effective work from the standpoint of the pupils' efficiency.

This paper aroused much interest and it was followed by an extended discussion led by Mr. G. O. Banting, Stoughton, Wis., who stated that one means of making the courses in science effective is to experiment and to publish the results. "We should interest the child more than at present."

J. W. Shepard spoke for social efficiency. "Would not limit the topics of study."

E. E. Burns: "I would introduce significant material. There is danger of swinging too far in the new movement."

G. R. Twiss: "We must appeal to the real interests of the child. Often too few connections are made between schoolroom habits and outside habits, schoolroom ideas and home ideas. A logical scheme in a study belongs to the end instead of the beginning of education."

A paper well worth the thoughtful study of every science teacher was read by Professor W. C. Bagley, of the University of Illinois. Its subject, "Testing for Efficiency of Work," will be published in the Proceedings, and is full of helpful ideas. "Measurement of mental content must be objective; we cannot measure *subjective factors* as such." "Dependable knowledge has a firm foundation in fundamental habits." Scores of apt quotations could be made from this paper. It aroused and stimulated

the teachers present and led to a general discussion. A. A. Upham enlivened the program with one of his inimitable optimistic speeches. Chairman Terry gave some practical suggestions as to real tests of a pupil's knowledge, such as a "leaking boat" and a "weighted clothesline."

F. R. Nichols: "Examination papers show only part of the results. Oral tests are also very useful."

J. W. Shepard: "Pupils on being asked the question, 'What science do you like best?' usually name the one they can use best."

C. H. Perrine, Chicago: "Give pupils in an examination a chance to ask and answer a question on some topic."

G. H. Twiss moved that "a committee be appointed to act as a central committee to receive, study and report upon tests made by members of this association to test the efficiency of their work." The chairman appointed the following members to serve as the committee: F. E. Goodell, North High School, Des Moines, Ia., Chairman; J. A. Stevenson, University of Wisconsin, Madison; C. M. Bronson, Central High School, Toledo, Ohio; J. W. Shepard, Teachers' College, Chicago, Ill. It is earnestly requested that each member of the Physics Section send in to the committee, lists of test questions, together with any plans or means that may be employed in testing the efficiency of the instruction or any other phase of the work in physics.

At the session held Saturday morning, the nominating committee reported the following nominations: Chairman, E. E. Burns, Medill High School, Chicago; Vice-Chairman, William M. Butler, Yeatman High School, St. Louis; Secretary, E. R. Reynolds, State Normal, Platteville, Wis. On motion, the secretary was directed to cast the ballot of the section for those named, and it was cast as ordered.

The first paper, by Willis E. Tower, Englewood High School, Chicago, was a report of a committee upon a questionnaire which had been suggested at the Cleveland meeting as a means of determining the extent, the tendencies, and the apparent success of the educational experiment of teaching physics in segregated classes. The report, which is printed in full in the Proceedings, aroused considerable discussion. C. M. Turton moved that "the report of the committee be accepted and the committee be commended for what it has done."

It was further moved that the committee be continued and report at the next meeting.

E. E. Wolfe, Marietta, Ohio, suggested that a syllabus for segregated classes would be desirable.

Professor P. B. Woodworth, of Lewis Institute, next presented the topic "The Laboratory—Its Work and Apparatus." The subject was effectively presented, and the unique and successful methods employed by Professor Woodworth in his work in physics were illustrated by a series of typical experiments. It is the constant aim in this laboratory to make its experimental work conform to the methods and practice of practical men outside of schools. A number of important pedagogical points were emphasized, of which a few only can be presented here. (1) For the most effective laboratory work, *real* problems must be presented. (2) A *real* report should be required, in which the essential factors involved are clearly indicated. (3) The habit of getting results *quickly* and *on time* is of great importance. (4) Some laboratory teaching may be immoral, as when results of impossible accuracy are required. (5) Various methods of teaching may bring good results. (6) It is important to give the boys just the things they want.

The evening adult classes at Lewis Institute have stimulated the intro-

duction of practical methods and real problems into the laboratory work.

The device by which the school auditorium at Lewis Institute is quickly transformed into a physics lecture room, equipped with appliances for demonstrating any subject in this science, and as readily restored to its former condition, aroused lively interest and curiosity among the members present.

Professor Woodworth concluded the demonstration of his work at Lewis Institute by passing around a number of sheets of laboratory directions and report blanks as used in his classes.

The meeting then adjourned. WILLIS E. TOWER, *Secretary.*

PERSONAL.

Professor G. A. Miller's article entitled "Appreciative Remarks on the Theory of Groups," which appeared in the April, 1910, number of SCHOOL SCIENCE AND MATHEMATICS, has been reprinted "by permission" in the October, 1911, number of the *Mathematical Gazette,* organ of the Mathematical Association of England; and also in the August, 1911, number of the *Sphinx-Œdipe,* published at Nancy, France.

TESTING PHOSPHATE ROCK.

For the benefit of those who may search for phosphate rock the following simple test is given: Place a small crystal of ammonium molybdate on the rock to be tested, then drop a little dilute nitric acid on the crystal. If the crystal turns yellow, it indicates the presence of phosphorus. The deeper the yellow, the higher the phosphate content.

APPOINTMENT OF CHIEF GEOLOGIST, UNITED STATES GEOLOGICAL SURVEY.

The United States Geological Survey announces the appointment of Waldemar Lindgren as chief geologist, to succeed C. Willard Hayes, who recently resigned from the survey. Mr. Lindgren has been a member of the federal survey since 1884, and has been in charge of its investigations in metalliferous deposits since 1907. He is the author of some fifty reports published by the survey and, in addition, has contributed between fifty and sixty articles to technical and scientific journals. Mr. Lindgren is a trained mining engineer and has a world-wide reputation as an authority on the geology of ore deposits.

REPORTS OF THE AMERICAN COMMISSIONERS, INTERNATIONAL COMMISSION ON THE TEACHING OF MATHEMATICS.

The following reports have thus far appeared; copies may be obtained gratis by addressing the Bureau of Education, Washington, D. C.

1. Training of Teachers of Elementary and Secondary Mathematics.
2. Examinations in Mathematics Other Than Those Set by the Teacher for His Own Classes.
3. Mathematics in the Technological Schools of Collegiate Grade in the United States.
4. Undergraduate Work in Mathematics in Colleges of Liberal Arts and Universities.
5. Graduate Work in Mathematics in Universities and in Other Institutions of Like Grade in the United States.

BOOKS RECEIVED.

Microbiology for Agricultural and Domestic Science Students. Edited by Charles E. Marshall, Michigan Agricultural College. Pp. xxi+724. 15x20 cm. Cloth. 1911. $2.50 net. P. Blakiston's Son & Co.

Elements of Applied Mathematics. By Herbert E. Cobb, Lewis Institute, Chicago. Pp. v+274. 13x19 cm. Cloth. 1911. $1.00. Ginn & Co., Boston.

The Evolution of Plants. By D. H. Scott. Pp. 243. 13x18cm. 1911. 75 cents. Henry Holt & Co., New York.

Revolving Vectors. By George W. Patterson. Pp. vi+89. 14x22 cm. 1911. Cloth. $1.00 net. The Macmillan Company, New York.

Practical Methods in Arithmetic. By John H. Walsh. Pp. iv+395. 13x19 cm. Cloth. 1911.

Complete Arithmetic. By Bruce M. Watson and Charles E. White. Pp. viii+404. 14x19 cm. Cloth. 1911.

Elementary Arithmetic. By Bruce M. Watson and Charles E. White. Pp. vii+310. 14x19 cm. Cloth. 1911. D. C. Heath & Co., Boston.

The Elements of Qualitative Chemical Analysis. By Julius Stieglitz. Volume 1, Theoretical Part. Pp. 312. Price, $1.40 net. Volume 2, Laboratory Manual. Pp. 151. Price, $1.20 net. 1911. The Century Co., New York.

The Teaching of High School Mathematics. By George W. Evans. 1911. Pp. 94. Houghton-Mifflin Co., Boston, Mass. Price 35 Cents.

TUNGSTEN A REMARKABLE MINERAL.

The mineral tungsten (the name meaning heavy stone) has been known for many years, but only comparatively recently has it become of economic importance. The most important use, according to Frank L. Hess of the United States Geological Survey, and the one which makes tungsten mining on an extensive scale possible, is as an alloy for tool steel. Lathes using tools made from tungsten steel may be speeded up until the chips leaving the tool are so hot that they turn blue, an operation which would ruin the temper of high-carbon steel. It is stated that about five times as much can be done with lathes built for such speed and work as can be done by the same lathes with carbon-steel tools. From 16 to 20 per cent of tungsten is ordinarily used in lathe tools. The melting point of tungsten is exceedingly high—5,576° F.

Tungsten also has an important use in making incandescent electric lamps, crucibles for electric furnaces, and various other articles.

MINERAL PRODUCTION SECOND ONLY TO AGRICULTURE.

Nearly a third of a billion dollars was added to the wealth of the United States from the mineral production of the Western States during 1910, according to the figures of the United States Geological Survey. This includes about $66,000,000 worth of coal, the remaining production, principally metals, having a value of practically a quarter of a billion dollars. The total figures of Western mineral production as compiled by the Survey are $313,944,881. This is about one fourth the total agricultural production of the same area, the proportion between mineral and agricultural production being about the same as for the entire United States. The agricultural production of the Western States, derived from figures of the Department of Agriculture, was approximately $1,394,791,000. The area considered includes the belt from the Dakotas south to Texas and the territory westward.

BOOK REVIEWS.

The Theory and Practice of Technical Writing, by Samuel C. Earle, Tufts College. Pp. vii+301. 14x19 cm. Cloth. 1911. $1.25, net. The Macmillan Company, New York.

This is a book which ought to have come from the press two-score years before this date. Technical writing belongs in a class by itself. From many points of view it is distinctly different from that of general literature. Too long has the technical man been obliged to receive the same kind of instruction in English and composition, in college and university, as the man in the general arts course. This situation ought not to exist longer. If courses in technical composition similar to that outlined in this book had been in operation for the last thirty or forty years, many technical writers would have made themselves better understood and likewise the general public would have a better knowledge of technical matter. The engineer and technical man must write from a field which is peculiarly his own, using phrases and a vocabulary which are distinctly technical. Apparently the teachers of English have not heretofore been able to differentiate between straight English and that of the technical world. This book does not attempt to give one skill in technical writing only in so far as the person makes use of the suggestions and helps which it contains.

The book is divided into two parts, the first being given to a study of the principles of logical structure and the second to practical applications of principles. The subject matter in part one is treated in six chapters, as follows: Analysis by means of synopses; fundamental principles; descriptive exposition; narrative exposition; directions and descriptions. narration and directions combined. Part two contains five chapters discussing the matter under the following heads: The essentials of logical structure; addressing general readers; addressing specialists; the form of the final writing and methods of writing. The appendix gives many illustrative examples of technical writing. A good index is appended. It is a splendid book considered from any point of view, and deserves, as it undoubtedly will have, a large circulation. C. H. S.

The Hindu-Arabic Numerals, by David Eugene Smith and Louis C. Karpinski. Pp. vi+160. 14x20 cm. 1911. Price, $1.25. Ginn & Co.

Much has been written on the origin of the symbols we use to express numbers, and the many conflicting theories offer no real solution of the difficult problem to the ordinary person. Hence this book will prove of great value to all teachers of mathematics since it gives the results of a careful investigation of the whole question.

"In the preparation of this treatise the authors have examined every important book and monograph that has appeared upon the subject, consulting the principal libraries of Europe as well as America, examining many manuscripts, and sifting the evidence with greatest care. The result is a scholarly discussion of the entire question of the origin of the numerals, the introduction of the zero, the influence of the Arabs, and the spread of the system about the shores of the Mediterranean and into the various countries of Europe."

The numerous facsimiles from early inscriptions and manuscripts are of great service in helping one to an understanding of this problem. This contribution to the history of mathematics should find a place in the library of every teacher of mathematics. H. E. C.

Essentials of Biology, presented in problems, by George William Hunter, A. M., Head of the Department of Biology, DeWitt Clinton High School, New York. Pp. 448. 1911. American Book Company.

The scope and point of view of the book may best be given by a quotation from the preface. "The functions of all living things, plant or animal, movement, irritability, nutrition, respiration, excretion, and reproduction; the inter-relation of plants and animals and their economic relations, all these as they relate to man, should enter the course. The culmination of such an elementary course is avowedly the understanding of man, and the principles which hold together such a course should be chiefly *physiological.*"

As indicated by this quotation, the book contains studies of animals and plants, and concludes with chapters on human physiology. It is intended for pupils in the first year of the high school. Also, as the title indicates, the treatment of the various topics is put in the form of a series of problems. The first problems are those relating to plants for the most part, but including the inter-relation of flowers and insects. This is followed by a chapter on the general relations of animals to plants and then by a series of chapters on animals in evolutionary order, finally concluding with "man as a mammal" and human physiology.

So far as the reviewer is aware, this is the first attempt by an American writer to produce a text book based on the topic or problem plan instead of the time-honored evolutionary plan. Jordan and Kellogg, and later Kellogg, in some of their text-books abandoned in a large degree the evolutionary plan. The topic method of presenting the subject of biology was advocated by Professor H. E. Walter in an address at Clark University in 1909, which was later published in SCHOOL SCIENCE AND MATHEMATICS, volume 9. The writer of this review is heartily in sympathy with the effort to present the subject of biology in a series of topics rather than by the one great topic, evolution. This is too far removed from the experience of young students to be made the one and only motive of a course for such students. It has been a very good method for killing enthusiasm in the subject.

The book is simple in style and presented in a form that will appeal to the student it aims to reach. The relation of man to animals and plants is wisely made much of throughout the book.

There are some faults to which any just review must call attention. The most important of these is the splitting up of the subject into too many apparently co-ordinate topics and crowding into these practically all that might go into three text-books—zoölogy, botany and physiology. It would seem that the author could not let anything go from his grasp, and so has brought into this one volume an array that certainly must prove bewildering to first-year students. The casting of a portion into fine print does not help much. These portions should have been weeded out and only the *essential* portions given. The author, in his desire to present every interesting fact, has committed the very sin which he says he is avoiding. He quotes from President Remsen: *"The most important defect in the teaching of chemistry to-day is the absence of repetition. There are too many fleeting impressions. We cover too much ground. The student gets only a veneer."*

There are many good points in the book, and it should prove a very useful book for any teacher of biological subjects to own, whether he uses it in his classes or not. We trust that there will be evolved in the near future, a text-book of biology with the aims of this book, but more sanely put together; and that whenever the first year of such a course in biology is given, it shall be followed by an optional year of zoölogy or botany. W. W.

A History of the Ancient World, by George Willis Botsford, Columbia University. Pp. xviii+588. 15x19 cm. Cloth. 1911. $1.50 net. The Macmillan Company, New York.

Many histories of the ancient world have been written for secondary school work; none, however, cover the ground so thoroughly, or make the matter so clear and interesting to the pupil as this one. It is practically rewritten from its first edition and has been prepared to meet present-day needs, both as to college entrance requirements and state examinations, as well as to give the reader a splendid working knowledge of the history of the world covering the time for which it was written.

Among the many strong features is the abundance of new maps and typical illustrations. There are twenty full page and double page maps, seventeen maps and plans, eighteen full page illustrations, and 154 illustrations in the text. It is divided into three parts. Part one, of forty-eight pages, is given to the Oriental nations. Part two, of 244 pages, is devoted to Hellas, and the balance to Rome. At the end of each one of forty-six chapters is given a list of suggestive questions on the matter treated in the chapter, also a list of topics for readings is given.

Mechanically the book is well made. The chief paragraphs, of which there are 508, begin with bold face type. A bibliography is given of helpful books. A complete index of twenty pages is printed at the end. Schools will make no mistake in selecting this text for their classes.

C. H. S.

Guide to the Insects of Connecticut, prepared under the direction of Wilton Everett Britton, Ph. D., State Entomologist. Pp. 169. Plates xi. Issued as Bulletin No. 16, by the State Geological and Natural History Survey of Connecticut.

This bulletin consists of two parts, part one being a general introduction to the study of insects, written by Mr. Britton, and covering thirty-eight pages, while part two contains a key to the euplexoptera and orthoptera of Connecticut, prepared by Benjamin Hovey Walden, B. Agr. There are a good many cuts to explain the text and the keys and many of the insects named in the lists are figured in the plates. The bulletin will be very helpful to those interested in these orders, but more especially to teachers who are in much need of keys which can be used by students not versed in the extensive nomenclature usually found in keys to the insects. The bulletins are distributed gratuitously to institutions of learning and to teachers in need of them. W. W.

Five Hundred Regents' Questions in Biology and Zoölogy, by S. C. Kimm, District Superintendent, Herkimer County, N. Y. Pp. 41. C. W. Bardeen. 1911. 25 Cents.

The questions contained in this booklet are selected from past examination papers used by the regents. The questions, numbering over 500, are accompanied by references to standard texts, usually several references being given for each question. The questions are grouped, those relating to a division of animals being brought together under the name of the division.

The questions are elementary in character, brief and clearly stated. For those who may wish to review and freshen their knowledge of zoölogy, or who may wish to pass such examinations as are given by the regents, the book would be valuable. The book might be used to advantage by students taking elementary zoölogy, or by students who may wish to gain a knowledge of zoölogy privately. W. W.

Laboratory Manual of First Year Science, by Joseph L. Thalman and Ada L. Weckel of the Oak Park, Ill., and River Forest, Ill., High School. Pp. 93. 1911. Ann Arbor Press, Ann Arbor, Mich.

The content, purpose and method of high school sciences are undergoing fundamental changes. Certain aspects of these changes are conspicuous in the work of the first year general science. Such work has been advocated very generally throughout the whole country during the past two or three years, and has been and is still being tried in many schools. In the Oak Park and River Forest Township High School the general science course has long since passed the stage of initial experiment and has taken fairly definite form. After twelve years of trial under several teachers with the expert guidance of Principal John C. Hanna, there has now been prepared a laboratory guide which outlines the work of the course. More than ordinary attention should be given to this publication for several reasons: Principal Hanna is one of the pioneers in the general science movement; the course, as taught, has stimulated the sympathetic interest of a large number of visiting teachers; the course has been made by several high school people who believe in science for efficiency; in one form or another the course has been tried with "about one hundred sections" or classes; the outline as published is clean-cut and direct, and has a modesty that has kept it within the limits of the experiments that have been tried; it may not be the final solution of the general science problem, but in presenting in definite form this one successful general science course, it will be a potent, possibly the most potent contribution, toward solution of the general science problem; its basis is in prolonged and careful experience, not in argumentation.

The authors and their principal, as part of the result of this prolonged educational experiment with science have presented some important conclusions, which we quote in part; they state:

That, "a child's first knowledge of science does not deal with the differentiated sciences as such. He comes in touch with science in all its phases. Certain preliminary science study of some sort should be done in the high school before the regularly accepted laboratory courses in physics, chemistry, botany, zoölogy, and physiography are taken up;" and that "such elementary studies are advisable for all pupils," whether or not other science courses be taken later.

That, "aside from the training value of such courses, consideration should be given to the matter of content with reference to the practical usefulness of the actual knowledge acquired."

That, "some familiarity with the scientific method of attack thus acquired . . . . . . will tend to develop early the scientific habit which will be of use in every department of study."

That the aims enumerated "may be reached better by such a course than by any course confined to the facts and problems of any one of the fields of study."

The course consists of fifty-nine separate outlines or "exercises," each of which includes its topic heading, a statement of the object of the study, the apparatus to be used, and full directions and questions to guide in performance of the experiment or study. In the directions, statements of facts are included when such are needed in order to orient the pupil in the work under way. Illustrative figures prepared by students were made from the apparatus used in course of experimentation.

Since there is such wide variation in the content of courses in general science, in order to show the topics used in this course we present here the general headings under which the topics fall and in the order in

which they are given: Matter, its constitution and some forces which affect it; measurement of temperature and effect of heat upon the state of matter, changes in matter; chemical phenomena and elements; air and water; acids, bases and neutral substances; classification of foods; digestive system, digestion, absorption, respiration and circulation; the skeletal, muscular, excretory and nervous systems; bacteria; ventilation; seeds and seedlings, roots, stems, leaves; evaporation; the flower; classification of plants.

It does not appear from the manual that there is as close unity as might be desired between the different parts of this course. In certain other courses in general science physiography is drawn upon more largely than in the above course, and is used as the centralizing feature of the course. If better unity may be secured without losing any of the benefits that are derived, it should be done. But unity of the course, or of any particular science sometimes results in a logical but dead science, and vitality and motivated work must not be the price of unity. Unity and formalism in science teaching have too often been close companions. Furthermore, the kind of organization of material that is necessary to give the work appreciable significance to the beginning student may be very different from "the unity of the subject" that is seen by the adult scientist. A course as the above, which, through experiment, has "made good," should through that token demand the attention of science teachers.

O. W. C.

Principles of Rural Economics, by Thomas N. Carver, Harvard University. Pp. xx+386. 14x20 cm. Cloth. 1911. $1.30. Ginn & Company, Boston.

This is an entirely new type of book relating to agriculture. It treats of phases of this work which have not been to any extent written about. It differs from nearly all other books dealing with agricultural questions in that the discussions are mainly from the viewpoint of national economy, instead of the individual farmer. There is nothing in the book which will teach the farmer how to grow crops; the reader will, however, be convinced that the agriculturist wields an influence on national prosperity for which the urban resident is reluctant to give him credit.

Although agriculture is our largest and oldest industry, it is only comparatively recently that proper thought and attention has been turned in the direction of our great rural problem.

The wonderful interest which has been shown and taken in agricultural pursuits within the last decade even, shows that there is to be a movement away from the great centers of urban industry into the country where conditions more favorable for real living are to be found. The book was written in order that some of the questions of the rural problem might be brought to the attention of the public in the particular direction of the social side of the question.

The text is divided into six chapters, as follows: 1. General principles. 2. Historical sketch of modern agriculture. 3. The factors of agricultural production. 4. Management as a factor in agricultural production. 5. The distribution of the agricultural income. 6. Problems of rural social life. There is a splendid bibliography of eight pages.

The book to read is as interesting as a story, but infinitely more helpful. It ought to be read by everyone interested in the better social development of our people, and by those especially interested in the betterment of our rural conditions.

Mechanically, the book is well made, printed from electro plates taken from eleven-point, hand-set type. It should have a large sale. C. H. S.

The School of To-morrow. Pp. 152. 13x19 cm. Cloth. 1911. $1.00. Doubleday, Page & Company, New York.

This interesting book is a collection of prize essays from *The World's Work.* They show the trend of modern education is away from many of our old and established methods. The writers do not leave the reader with nothing but the flavor of criticism in his mind, but they suggest ways and means to supplant those which they would displace. The point is plainly brought out that the school of yesterday is not and cannot be the school of to-day. The themes of the essays and authors are as follows: The boy of to-morrow, Arthur D. Dean; The boy of to-morrow, Eugene M. Gollup; The girl of to-morrow, Benjamin R. Andrews; The girl of to-morrow, Edith Hedges Baylor; Half time at school and half time at work, Frank P. Stockbridge; How to choose a public school teacher, William McAndrew; The Albany Vocational School, Frank L. Glynn. School people should read this book; it will pay; by so doing your eyes may be opened to new things. C. H. S.

Microbiology for Agricultural and Domestic Science Students, edited by Charles E. Marshall. Pp. 724. 13x20 cm. 1911. $2.50, net. P. Blakiston's Son & Co., Philadelphia.

A staff of twenty contributors have collaborated in the preparation of this text. The eminence of its authors will be accepted, at least by non-professional workers, as guarantee of its reliability.

The limits set for the book are somewhat unusual, as indicated by its title. It is a work on microbiology rather than upon bacteriology because it includes in addition to bacteria, many other organisms which on account of similarity of technique and biological relationships, have come to be studied in becteriological laboratories. Thus trypanosomes, plasmodia, molds and yeasts are within its field equally with bacteria, and no apology need be offered if both plant and animal types are discussed within a single paragraph.

The first 184 pages are given to a study of the morphology, culture, physiology, and ecology of micro-organisms in general. This part does not differ markedly from the similar discussion in other standard texts. The remainder of the book is occupied with applied microbiology in which applications to agriculture and domestic science are particularly emphasized. The authors have not, however, allowed the limitation of the title to interfere with the development of the subject. The scope of the work is best indicated by the titles of divisions in this part, which are as follows: Microbiology of air, of water and sewage, of soil, of milk and milk products, of special industries (such as food preservation, alcohol, vinegar, vaccines, etc.), microbial diseases of plants, microbial diseases of man and animals.

The secondary school teacher and the lay reader are likely to turn less frequently to the first part of the book than to the section composed of applied material, since most of us are less interested in the details of metabolism than we are in the relations of micro-organisms to the affairs of life. At the same time, anyone possessing the book would be unwise indeed to omit study of the very illuminating discussion of the nature and activities of these organisms as presented in the earlier chapters.

The breadth of the treatment of the applications of the science and its intimate association with existing problems is gratifying. Much of it would appear somewhat technical to the reader who has not had a biological training, but to one with such training, even of a very elementary sort, it should present no considerable difficulty. Every

biology teacher should be familiar with these matters, and there is not known to the reviewer any other single volume within which so much of value may be found.

The value of the book for reference purposes is enhanced by a very complete table of contents, an index of organisms, and an index of subjects. The paper is good, the type very clear, and the binding such as to give great flexibility. The mechanical execution is excellent. One is compelled to regret that such an admirable work is marred by an unusual number of errors in spelling and composition, all of which are apparently due to careless proofreading. W. L. E.

A Laboratory Manual for the Solution of Problems in Biology, by Richard W. Sharpe, Instructor in Biology, De Witt Clinton High School, New York. Pp. 352. 1911. American Book Company.

This manual was written to accompany Hunter's "Essentials of Biology" and, consequently, covers the same field and in about the same manner, but as a manual instead of a text. It has the same excellent features as to aim and matter as the text-book it accompanies. It also has the same fault of overcrowding as the text. This will be better appreciated when it is noted that the book contains 352 pages of studies intended for first year pupils to accomplish in one year. True, the author asserts that much more is given than is required in order to give variety and give brighter pupils a chance for extra work. But, allowing for this, there is still a very large mass of new facts and ideas to be digested in one year.

The lessons or problems are clearly stated and the questions for observations short and clear-cut. Each lesson consists of a statement of the problem, a list of materials required, and questions for observations, followed by questions for conclusions to be deduced from the observations. According to the author's suggestions for using the manual, the questions for observations are to be answered by the pupils orally, then the pupils write the answers to the questions for conclusions. These answers are then read by the pupils and criticised and, finally, the entire study is written out by the pupils for handing in as completed work.

Such a scheme as this may be desirable for large classes of first-year pupils, but it is hard to see how it could be prevented from becoming machine-like in its precision. The quick-witted pupils would always benefit most, unless held back. Much more ground can be covered undoubtedly by such a process, but at the expense of the originality and independence of the duller pupils. First-year pupils need guiding, it is true, and the lessons should be direct and simple, but so far as possible each pupil's identity should be preserved.

There are many good features of the book which there is not space here to enumerate. The extensive list of references given for each chapter should be very helpful for the teacher, and there are numerous tables which are very suggestive. We hope to see more manuals written taking up the biological subjects from the problem standpoint. W. W.

VANADIUM A STEEL TOUGHENER.

Remarkable claims are made for the toughness added to steel through the use of small quantities of the metal vanadium, according to a report of the United States Geological Survey. It is declared that after treatment with vanadium steel has great resistance to the strain, or as it is termed, the fatigue, caused by constant bending.